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DISCOVERY

A Monthly Popular Journal of Knowledge

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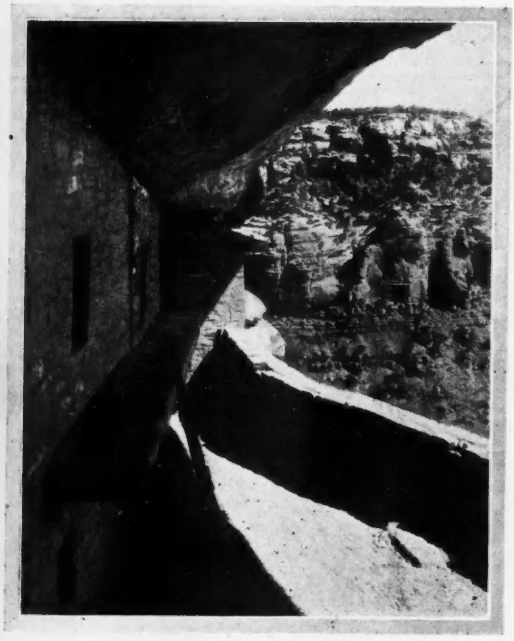

A MEDIAEVAL COMMUNITY DWELLING.
(See page 278)

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Notes of the Month.

This month scientists from all parts of the world will meet in London to celebrate one hundred years of British science. The centenary meeting of the British Association is in any case bound to be of unusual interest; several events will help to make the occasion unique among celebrations of the kind. In the first place, a principal object of the Association laid down in 1831 was "to promote the intercourse of those who cultivate science in different parts of the British Empire." The President for 1931, General Smuts, is both a distinguished scientist and an outstanding figure in Imperial politics. Secondly, the meeting will coincide with the Faraday celebrations, commemorating one of the greatest scientists of the past hundred years. An exhibition of Faraday's work will be shown in the Albert Hall where, on 23rd September, General Smuts will assume office in succession to Professor Bower. Lastly, this important period in the history of science will be reviewed in addresses by several of the pioneers who have contributed to its achievement.

* * * * *

On another page the present position of the British Association is discussed by Mr. O. J. R. Howarth, the secretary, and forms the chief feature of our special number. Since its foundation in 1920 the aims of *Discovery* have been similar to those of the Association, with the result that some of its contributors have spoken at every meeting during this period. The present meeting will be no exception. Two of the sectional presidents are members of our Committee—Sir J. J. Thomson (Mathematics and Physics), who is also our senior Trustee; and Professor C. S. Myers (Psychology). Many subjects in the programme have been dealt with in this journal recently. For example, "Insects and Man" (Zoology) was discussed by Professor Julian Huxley with reference to ants, while "The Distribution of Plants" (Botany) has been the theme of several articles by Professor Seward. "Broadcasting and Education," a subject for discussion appropriately chosen by the Educational Science Section, will interest readers who remember the articles which Mr. Edward Liveing wrote for *Discovery* not long after the B.B.C. was founded. Many of his predictions have come true, and already the new headquarters of the B.B.C. are nearing completion. The British Association has, as usual, arranged a series of Evening Discourses, and Sir Oliver Lodge is sure to attract a big audience for his "Retrospect of Wireless Communication." We shall publish a full report of the centenary meeting later.

* * * * *

Few British birds have been the subject of more prolonged attention than grouse. They have been rigidly protected by law since a Scottish Act of 1427 and have enjoyed the doubtful advantage of being studied by a series of parliamentary commissions. The movements of grouse, however, still form one of the problems of bird migration about which little is known. An interesting marking experiment was described by Professor James Ritchie, of the University of Aberdeen, in a recent letter to *The Times*. Grouse have hitherto been regarded as parochial birds, typical examples of the small group which lacks the roaming spirit. But Professor Ritchie believes that this view is mistaken, and that while grouse do not take part in regular migrations overseas, they are subject to certain mass movements of which the cause and extent are not yet understood. Keepers are familiar with cases where the birds have been plentiful in the spring but have disappeared almost entirely when shooting commences. This is among the problems which still await solution. Last spring numbered

rings were placed on some hundreds of grouse and a record has been kept of the moor on which every bird was marked. Sportsmen are now asked to look out for the ring on the feet of the birds and to communicate their observations to Professor Ritchie. In this way it is hoped to throw new light on the nature and extent of grouse movements. The results of the experiment will be awaited with interest by bird watchers, and it is hoped to publish an account of the observations in a future issue of *Discovery*.

* * * * *

Important discoveries are expected to be announced by Sir Douglas Mawson, leader of the "Discovery" expedition which has just returned from the Antarctic. Seven hitherto uncharted regions were discovered and a thousand miles of new coast have been claimed as British territory. Sir Douglas left the ship in Australia and the material collected during the expedition is at present awaiting examination at Adelaide University. Among the results, the discovery of two new whaling grounds may be regarded as highly important, while the film of the voyage forms a fascinating pictorial record. The "Discovery II" has also returned from an expedition in the interests of the whaling industry and an account of the voyage will be included in our October issue.

* * * * *

The International Institute of African Languages and Cultures has received from the Trustees of the Rockefeller Foundation the promise of a grant of £10,000 per annum for a period of five years. This is to be devoted to research in the cultural anthropology and linguistics of Africa. The grant is divided into two amounts of which £5,000 annually is receivable unconditionally, the balance of £5,000 per annum being payable at the rate of £1 for every £2 raised from other sources. This generous assistance should enable the Institute to carry out the plans for organized research in subjects related to its objects which it has had in contemplation since the time it was founded a few years ago. A scheme of work is now under consideration and will be submitted to the Executive Council at its next meeting in Paris in October.

* * * * *

Mr. Speden Lewis' plea for the protection of wild animals at the recent meeting of the Society for the Preservation of Empire Fauna recalls Major Hingston's article on "Animals Our Children Will Not See" in *Discovery* for February. The author showed how the progress of trade and cultivation is causing the extermination of many rare species, and he stressed the urgent need for the establishment of national sanctuaries. It is interesting to learn that the Society for the Preservation of Fauna is arranging the dispatch of a mission to West Africa in November, when the possibilities of a national park will be explored. Efforts are also being made to investigate conditions in Labrador, and it is to be hoped that negotiations will meet with more encouragement than those in Nyasaland where the game department has recently been abolished, paradoxically enough, "for reasons of economy." Too much importance cannot be attached to the work of the Society which is at present unfortunately hampered by lack of funds. Travellers in various parts of the Empire are continually reporting that whereas thousands of wild animals were to be seen on certain journeys a few years ago, only two or three are now encountered. A case in point is that of the Indian rhinoceros, which is the victim of such widespread poaching in Assam that vanishing point is already in sight. Mr. Speden Lewis emphasized the value to future generations of preserving Empire fauna, since our descendants might well find in certain rare species a significance which is not at present clear.

* * * * *

The production of shoes from sugar is among the possibilities of a remarkable discovery for which two American chemists are responsible. After many years of research the discoverers have successfully produced a material of which it is claimed that the uppers of shoes can be made. A variation of the method of treatment results in a non-inflammable cellulose film which is said to be more brilliant than celluloid. The discovery is the result of a new method of polymerizing sugar and the cost of the material is considerably less than that of an artificial "rubber" recently produced by a German chemist. The discoverers are confident of the commercial possibilities of the new material, especially in the event of a probable rise in the price of rubber.

* * * * *

The embarrassment associated with sitting for one's portrait is likely to be removed if a new process of self-photography proves practicable. The object is "to stimulate portrait-photography by making it more natural and more pleasant"; and while the wisdom of the invention is open to question, it is to be commended if it succeeds in producing more pleasing results. The apparatus comprises a cabinet containing five apertures, and the sitter is thereby enabled to study a series of poses from various angles. A button is pressed, and the exposure is made through one of the apertures. It is claimed that there is an additional advantage in the fact that "greater depth and definition" is obtained in the negative exposed through the aperture.

The Centenary of the British Association.

By O. J. R. Howarth, O.B.E., M.A.

Secretary of the British Association.

"The British Association for the Advancement of Science stands on the threshold of its second century with the mechanism and tradition of its founders unimpaired. At the time of its jubilee it passed through a period when some declared that it had finished its work; it had not then, and it has not now."

Of those to whom it is due to pay honour on the occasion of the centenary of the British Association, David Brewster stands first, for it was he who in an article in *The Edinburgh Journal of Science*, and on other occasions, first gave overt expression to the conception of a society of British cultivators of science.

Laying the Foundations.

The phrase is his, and is sonorous in accordance with his own style and that of his day; but there seems no reason to suppose that he would have assigned it formally to the new association. And though he indeed dug the ground for the foundation, other hands laid the stone. He, it is evident, willingly conceded them the honour; in fact, he passed it to them deliberately. For it was at his instance that York undertook to be the birthplace of the Association, and it is hard to believe that he could have chosen more wisely.

The Yorkshire Philosophical Society was clearly flourishing under the capable guidance of William Vernon Harcourt, John Phillips and others; it was evidently qualified to summon a representative meeting of cultivators of science in a provincial centre. Counsels less wise than Brewster's might have led to summoning the foundation meeting of a great national institution to take place in London—which easily might have meant failure. York was a geographically favourable centre to which all who were eager for the success of the new venture could easily repair; but it was improbable that those who were not eager would be at the pains to travel to York or anywhere else in order to say so. There were persons in this second category, and they said their say in correspondence and through the medium of the Press; and a first meeting in London might have given them too good an opportunity at the outset. It was clearly better to begin as it was intended to continue: the Association expressly contemplated no invasion of the ground occupied by the great learned societies, of which so many were founded in the two decades on either side of the Association's establishment.

The principal officers of the Yorkshire Philosophical Society took the helm of the ship when Brewster offered it to them, and handled it most ably. The Society had been established in 1821, with the immediate purpose of maintaining the Yorkshire Museum, the nucleus of which was a collection of bones of extinct animals from Kirkdale Cave near Kirkly Moorside under the hills of the North Riding. The Museum still occupies the place in which it was established, in a building adjacent to some of the Roman fortifications of the city and the ruins of St. Mary's Abbey. In 1831 Viscount Milton was president, William Vernon Harcourt was vice-president, Jonathan Gray treasurer, John Phillips and William Gray secretaries. These were elected to the same offices in the new association, and among them Harcourt stands out as the maker of the Association's constitution and its first regulations.

Harcourt was a son of the then Archbishop of York, and was himself a canon of the cathedral. He had received an education for the navy before he proceeded to study for holy orders. The tradition of scientific lore was still, at this period, preserved among those who served the Church—the proportion of these among the first committees of science in the British Association is remarkable—and Harcourt was an eminent amateur in chemistry and other departments of science.

Far-sighted Pioneers.

Harcourt was evidently a man of very wide interests, and it was that trait above all which aroused his interest and made him a leader in the establishment of the British Association, as is clear from the speech in which he outlined its aims, its constitution, and its proposed working. That speech is recorded, and in its way it is a masterpiece. It is well worth considering to what length his ideas and those of his colleagues have shown the way to their successors. For these men saw very far; in nearly all essentials they saw as far as the Association has now gone.

"Some differences of opinion may exist," he said,

" as to the want in which we stand of a new association, to give a stronger impulse and a more systematic direction to scientific enquiry." He made it clear that he did not rest his opinion of this want upon any complaint of the decline of science in England. " There is good reason, indeed, to regret that it does not make more rapid progress in so favourable a soil, and that its cultivation is not proportionate to the advantages which this country affords and the immunity from vulgar cares which a mature state of social refinement implies." This had been one of Brewster's favourite themes. But Harcourt recognized, what is very obvious at this distance of time, that the broadening of interest in science was evidenced by " the list of philosophical societies which have grown up in all parts of the kingdom."

" Numerous Institutions."

" The multiplication of these new and numerous institutions," said Harcourt, " indicates a wide extension of scientific pursuits. The funds so liberally contributed to their support bear evidence of an enlarged disposition in the public to promote such pursuits." Here the speaker was more easily satisfied than most of his successors have found themselves.

But the main interest in this part of the speech lies in the moral which is drawn from this form of activity in the organization of science. " It is on this very ground I rest the necessity and the practicability of establishing in science a new impulsive and directive force, that there are new and more abundant materials to be directed and impelled. Consider the differences between the limited circle of any of our scientific councils, or even of the annual meetings of our societies, and a meeting at which all the sciences of these kingdoms should be convened, which should be attended by deputations from every other society and in which foreign talent and character should be tempted to mingle with our own. With what a momentum would such an association urge on its purpose ! " There follows a bold thrust at the Royal Society for having failed in this portion of the task of promoting scientific advancement. But however much of overlapping there may have been in organization (and we are not free of it now) events have indicated that in this particular direction Harcourt's criticism was for once at fault. But he got back on to sure ground. " When any science becomes popular, and those who interest themselves in its advancement perceive the necessity of working for it by united exertions, that science is detached from the central body ; first one fragment falls off and then another ; colony after colony dissevers itself from the declining empire, and by degrees the commonwealth of science is dissolved.

" The new societies distinguish themselves by their diligence and activity ; the parts of knowledge which thus receive more distinct attention, and are propelled by more undivided labour, make rapid advances ; and each separate undertaking justifies itself by the most promising appearances and undeniable fruits. This is a new stage in the progress of science ; a new state of things which, whilst it is attended certainly with great advantages, has some consequences of doubtful aspect to the highest aims of philosophy." " The chief interpreters of nature have always been those who grasped the widest field of enquiry." " There is a defect in these separate societies . . . which arises from the narrow basis on which they are of necessity built." This is sufficient quotation to illustrate the point which Harcourt, with rare prescience, elaborated at length.

Has the Association, then, discharged this among the other duties which he laid upon it ? It can be claimed to have done so. It divided early into sections : that was inevitable and indeed was foreseen by the founders. And as some of these—biology, for example—became unwieldy, they were again divided into two or more. This, it may be argued with some reason, would seem to represent the process under which colonies dissever themselves from the declining empire, in the manner which Harcourt deplored. But the empire has not declined. Moreover, many of the associations in other countries, which have paid the British Association for the Advancement of Science the compliment of copying its title, have carried the division into sections very much further, and in at least one case the entity of an association is in some measure lost when some of its sections merge into meetings of specialist societies convened concurrently.

Co-operation between Sections.

But even a common period of meeting does something to give effect to Harcourt's ideal of co-operation. And in the British Association that tradition is still strong. That there are even in our own Association too many sections is arguable, and has been argued ; none of those sections, at least, which have been formed within recent years has been formed without opposition on this ground. But by general consent they have justified themselves ; moreover, the principle of co-operation between sections has never been lost to sight when appropriate occasions arise. In this direction, then, the Association may claim to have effected one of the major purposes for which it was founded.

Another such purpose, as phrased by Harcourt, was " to obtain a greater degree of national attention to the objects of science." " Scientific knowledge has of late years been more largely infused into the education of every class of society, and the time seems to be arrived for taking advantage of the intellectual improvement of the nation. Let philosophy at length come forth and show herself in public ; let her hold her court in different parts of her dominions ; and you will see her surrounded by loyal retainers, who will derive new light and zeal from her presence and contribute to extend her power on every side."

Collaboration of the Press.

At the time of the Association's foundation, and for a number of years after, there were those who appeared to regard this merely as an exhortation to self-advertisement. But it came to be recognized that the individual scientific workers who actively supported the Association were making a free gift of their knowledge to the community ; and more than this, many of them were devoting, as many of them still devote, long hours of unrewarded labour to maintaining the mechanism of the Association. It was found that parts, at any rate, of what the philosophers had to say were " news," at once intelligible and unknown to the public ; and thus it was that the Press became and has remained a faithful and essential collaborator of the Association in the effort " to promote general interest in science and its applications."

The writer has encountered more than once a view according to which the Association should carry the process of enlisting public interest in its transactions much further than it does—should cause its lectures to be headed with catch-lines and its posters to flare from every hoarding. But for his own part he cannot envisage the philosopher doing this for himself ; and in point of fact it is on suitable occasions most ably done for him. When the subject of an erudite communication to the psychology section (for example) reveals itself on a newspaper poster in the form " Why Babies eat Coal," it may be assumed that the speaker has discharged his duty to the public without being forced to incur the severer penalties of success. No philosopher in Harcourt's sense could evolve for himself an appeal to publicity in terms like these—at least, the gift is rare.

In a third direction the Association may claim to have ably discharged a duty laid upon it in 1831. Harcourt, in the speech already quoted, credited Whewell with discovering the necessity for " a collection of reports concerning the present state of science, drawn up by competent persons, in order that scientific students may know where to begin their labours, and in order that those who pursue one branch of science may know how to communicate with the inquirer in another." The Association's success in this direction need not be elaborated here—it has been demonstrated over and over again. The Association possesses, and has repeatedly exercised, a power of initiation very nearly peculiar to itself. It has carried that power into many fields of scientific investigation, giving the start for which its own deliberations have revealed the need and passing on the ultimate attainment of the objective to other organizations better fitted to achieve it. Nor does this process apply solely to researches initiated within the Association and carried out by individuals or committees. At the time (1842) when the Association assumed control of Kew Observatory there was no other body which could, or would, undertake that task, and thirty years later the control was resigned to other hands with the gratifying knowledge that a famous centre for scientific work was safe from extinction. And the mechanism of the Association has always been, and still is, capable of being geared on to new duties, provided that the necessary financial fuel be supplied to the machine, as Mr. Buckston Browne supplied it when he charged the Association, two years ago, with the custodianship of Darwin's home, Down House, as a national memorial.

The Association, then, stands upon the threshold of its second century with the mechanism and tradition of its founders unimpaired. It has found responsibilities not envisaged by its founders, and has discharged and is discharging them. It has widened the scope of its peripatetic meetings to embrace the Dominions—as more than one of its founders clearly foresaw. It has passed through a period (this was about the time of its jubilee) when some people said, quite loudly, that it had finished its work. But it had not then, and has not now. In 1831 there was no such immense number of scientific meetings, sectional, general, international, as there are to-day.

No Symptoms of Decay.

Yet the annual meetings of the Association continue without effort on the part of the permanent organization to find centres to undertake the onerous task of receiving them ; the Association is " bespoken " down to the year 1934. From the point of view of external interest Sir Douglas Galton's words in his presidential address (1895) may be borrowed : " We exhibit no symptoms of decay." From within, the present writer can only say that he has not noticed any.

The Cliff Dwellers of Colorado.

By George Woodbury.

Department of Archaeology, Colorado State Museum.

Although the mediaeval cliff dwellings of Colorado are not a new discovery, little is yet known of these remarkable community houses, built by the Indians in the canyons of almost unscaleable rock. The history of the Cliff Dwellers is now being studied by archaeologists in the light of remains which have recently been recovered.

THE picturesque cliff dwellings of south-west America have been known to archaeologists for nearly half a century, and our limited information concerning them and their now vanished inhabitants has increased yearly since their first exploration. Cliff dwellings are found to have been abundant at the point where the boundaries of the four states, Colorado, Utah, New Mexico and Arizona intersect. The "four corners" as this region is called locally is the only place where such a concurrence of boundaries exists. These unique ruins are most common in a district known as the Mesa Verde in south-west Colorado. The Mesa Verde might be called, in fact, "The Capitol of Mediaeval America" for the same reason that Les Eyzies is called "The Capitol of Prehistoric France."

Here there is a broad level plain of dun coloured soil, dappled here and there with the pale green of desert shrubs. In the centre of the plain and rising abruptly from its even surface is a mountain with its top cut away so that it presents the appearance of a huge truncated cone. This "mesa" formation is typical of the south-western landscape and the mesa here described takes its name from the dark green growth of pinon pine and fir trees that cover its flat summit. When one makes a tour of some twenty miles round the foot of the mesa one is struck by its fortress-like qualities. On every side a percipitous embankment of sheer rock rises hundreds of feet into the air. It seems unscaleable, and indeed the possibilities of climbing it are very few and difficult to find. It was on the top of this strange formation that the Cliff Dwellers selected to build their homes.

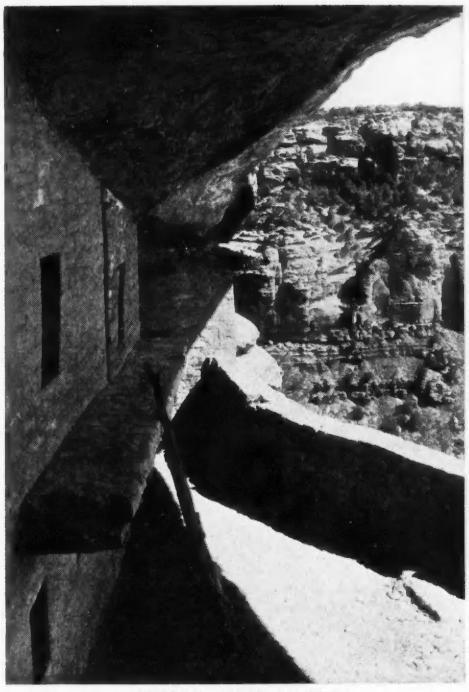
About 1880 Richard Wetherill, a rancher, discovered the existence of ruins on the mesa top. The story tells that he was riding over the mesa while hunting for some cattle he had lost when he saw the immense ruins of the "Cliff Palace" from the opposite side of the canyon. He returned in company with his brothers and together they not only explored the first ruins found but discovered literally dozens of similar structures in the vicinity. They were more or less ruined and bore every indication that they had been long abandoned. The Wetherill brothers soon found it far more profitable to conduct sightseers to the ruins than to ranch cattle, and became the guides to the region. At that time no law existed to prevent anyone from helping himself to whatever was found, and tons of specimens were pillaged by curio seekers. In 1906 the mesa became a National Park and under direct Government supervision. Since that time the ruins have been heavily protected; many have been to some extent restored, and all have been protected against the weather and vandals, the archaeologist's chief enemies.

THE HOME OF THE CLIFF DWELLERS.

The cliff dwellings owe their name to the nature of the surrounding country. The houses were built in caves in the vertical canyon walls, a few hand-holes cut in the rock being the only means of access.

The cliff dwellings owe their name to the strange place in which they are built. The top of the mesa is cut and scored by

innumerable canyons, and wherever Nature afforded a suitable cavern in the side walls of the canyons, the Cliff Dwellers would build their houses. A more protected and well fortified situation can hardly be imagined, for the houses were built in caves half way up the vertical walls of canyons with no access except a few hand holes cut in the rock. Moreover, they were built at the top of a nearly inaccessable plateau in the centre of a plain. It is clear that the site was not chosen for fancy alone ; the Cliff Dwellers must have had good reason to protect themselves so completely.



A TYPICAL CLIFF "HOUSE."
The buildings are constructed of masonry, cemented and plastered over with mud. They were community and not family habitations.

The buildings themselves are of well-laid masonry cemented and plastered over with adobe mud which soon dries to a rock-like consistency. It would be hard to find a name for the style of architecture. The inhabitants seem to have accommodated the houses to fit the caves in which they were built. The buildings are community and not family habitations ; in these days they would be called apartment houses. They could and probably did house an entire tribe at a time and some of the larger ones could accommodate several hundred people. The rooms are of two distinct types. The square small, often window-less living rooms and the drum-shaped underground ceremonial chambers. The living rooms which form all the visible structure are barely ten feet square at their largest, and the roofs are very low so that a perpetual stoop is needed to explore them. A simple, frequently T-shaped doorway provided light, ventilation and entrance, and a flat slab of stone, held in place by withes, served the purpose of a door. These rooms are built one on top of another up to the very top of the cavern, sometimes four or five storeys in height, and are similar to those found among the present Pueblo Indian of New Mexico and Arizona ; they were chiefly used for sleeping. The ceremonial chambers are again similar to those found in Pueblo Indian villages to-day. They are built underground and are drum-shaped with a low bench running round the wall. Entrance is gained through a hatchway in the roof by means of a ladder. A strange flue-like vent running through the wall and up to the roof provides ventilation. The question whether it was made for this purpose or some other is hotly disputed ; in any event it does ventilate ! These are the regular features of the "khiva" as they are called by the present Hopi Indians. They are seldom more than two or three khivas to a cliff dwelling and it seems clear that their purpose was to provide a meeting place for councils and ceremonies for the men of the clan. In the Pueblo villages each clan has a khiva of its own for this purpose. In the present Pueblos they are taboo to women except at ceremonial times and to the uninitiated, and are the place where the important religious meetings take place. Presumably a similar function may be attributed to the khivas of the Cliff Dwellers.

The pottery of the Mesa Verde is both plentiful and characteristic. Two kinds are always found together, the crude undecorated cooking pot with its rough exterior surface and the well-made storage and water jars of grey clay with complicated geometric designs drawn in black. The "corrugated" cooking ware is usually of a single, rather pot-like, shape although considerable range in size is found. The "black-on-white" vessels, which are really dark brown on grey, exist in a wide variety of shapes and sizes and were used for innumerable purposes. There are small seed jugs, larger wide-mouthed water jars, bowls, tankards, dippers, canteens and ladles of a surprising variety. The designs are often complicated and usually consist of straight-line geometric patterns. The skill and firmness with which the designs are executed is admirable. This pottery was never made on a wheel, as that invention was not known at this time. It was all moulded with the fingers from a plastic mass of clay.

If the Cliff Dwellers resemble the Pueblo Indians of to-day, it is in the women's work. The numerous examples of weaving that have been found among the ruins show that this was a highly developed art.

Cotton was cultivated and the thread spun on a spindle of the simplest rod-and-disk type. The fabric was woven on a simple hand loom. Not content with plain textiles, the Cliff Dwellers designed woven-in patterns in red and black, angular designs, triangles and zigzags reminding one of the blanket patterns of the Navajo Indians. The Yucca plant, so common everywhere in the south-west, also served a useful purpose to the weaver. Yucca sandals are found in great abundance. They are woven in several different patterns, usually consisting of a flat sole with loops for the toes and fastenings for the ankles, although a type of high boot like a buskin, woven of the same material, has also been found. Yucca matting is found wrapping the bodies of the dead. Undoubtedly it also served a purpose for the living, but just what we do not know. Baskets of willow splints are frequent; for the most part they are saucer-shaped and flat with designs woven in black upon them. Blankets were made in a strange manner and it is doubtful whether they can be considered a part of the weaver's art. Rabbit fur or the down from turkey feathers was laid up in the twist of cotton or Yucca thread, and the woolly ropes were then fastened side by side with plain thread running at right angles. The blanket must have been rather cumbersome and awkward but it would at least prove of considerable protection from the cold.

POTTERY FROM MESA VERDE.

Many beautiful examples of the potter's craft have been found at Mesa Verde. Black-on-white vessels, all moulded by hand, exist in a variety of shapes and designs, usually comprising a geometric pattern.

Wood was an important commodity for the Cliff Dweller, for while the walls of the cliff dwellings are of stone, the ceilings separating the storeys are of another construction. Round wooden beams were laid across through loop holes in the masonry, then, at right angles a layer of small saplings was laid close together, then a layer of brush, bark or grasses which was in turn carefully plastered over with adobe mud and smoothed off to form the floor of the room above. Ladders were needed to pass from one floor to the next, for stairs either had not been invented or they took up too much valuable space. In fact the nearest approach to stairs discovered are the shallow foot-and-hand holds pecked in the cliff walls which lead up to some of the buildings from the canyon below. The ladders were of the very simplest form, merely a tree trunk with notches cut into it at intervals to provide a grip for the fingers and toes. These were placed on the outside, leaning against the buildings in much the same way as one sees them in the modern Pueblo. Wood served a multiplicity of purposes as it does for the Indian to-day. Wooden planting sticks are found in great number. They are like the usual gardener's dibble except that they are about three feet long. This extraordinary length is understandable when we realize that corn to be successfully planted in this hot and arid country must be planted at least two feet deep in order to receive any moisture. The babies of the Cliff Dwellers were carried about securely strapped to flat wooden boards. When lashed in this manner the young Cliff Dweller could not wriggle himself free and fall over the cliff or get into mischief; the infant became very portable under these circumstances and could be easily carried on the mother's back or hung up on the end of a beam while the mother went about her work.

The bows were of wood but the arrow shafts were of reeds tipped with stone points. Several strange objects closely resembling the shaped wooden splits used by the medical fraternity a generation ago for broken legs were found. This may also have been their use among the cliff dwellers; certainly living in such a locality would be conducive to breaking bones. Indeed, the finding of a pair of crude but effective wooden crutches indicates that injuries to the legs were not unknown.

Where so much hewn wood is found the question arises as to the means of working this medium. The only trace of metal of any description that has been found was a small nodule of meteoric iron. It had never

been shaped for any purpose and it is reasonable to assume that it was picked up and treasured as a curio on account of its excessive weight. Stone tools are, however, found in abundance. Axes were fashioned from an oval pebble of suitable size. A cutting edge was ground on one end and a groove pecked round the middle to carry the hafting. They were hafted by a loop of a tough desert shrub known locally as the " skunk bush " from obvious peculiarities that it possesses. Heavy hammers were constructed similarly and were frequently axes that had lost their cutting edges or had been broken in use. Some of the hammers weighing as much as five to ten pounds were clearly made for no other purpose. Perhaps the commonest stone utensil found is the simple stone grinding mill or " metate." One flat stone is laid on the ground and another smaller one is held in the hand and rubbed back and forth to crush the corn into meal. The present Indians use exactly the same crude " metate " as their ancestors did centuries ago. On one occasion when we were excavating a prehistoric ruin in the south-west, a group of Apache with their squaws paid us a friendly visit. We had excavated a number of the stone metates and had piled them up on the bank. The squaws were deeply interested in them and spent some time in feeling their grinding surfaces and commenting on their respective merits. Finally we were asked if they could have one of them—good metates were so hard to find nowadays !

It is clear that the Cliff Dwellers were primarily agriculturalists and that corn was their staple article

A CLAY WATER JUG.

A hand-made water vessel bearing a characteristically geometric pattern. The designs are often complicated and are executed with remarkable skill and firmness.

THE CLIFF DWELLERS' TOOLS.

This photograph shows some of the Cliff Dwellers' tools and implements of war. The hammer is fashioned from an oval pebble and a branch of shrub forms the handle.

of diet. The corn fields were apparently on the level ground on the mesa top, not infrequently on the roof of the cavern which lodged their homes. Water was carefully conserved and used to irrigate the fields as the dim traces of their ditches still testify. Squashes, beans and pumpkins were also cultivated and contributed to their food supply. It is reasonable to imagine that hunting supplemented this purely vegetable diet to some extent, but it is unlikely that they ever relied on it at all heavily. Domesticated turkeys were raised and kept penned up in the dark recesses of the caves behind the buildings, but whether they were kept for their feathers from which their owners made blankets, or to eat, or for their eggs, or for all three purposes it is hard to say. The only other domesticated animal was the dog. He also may have served as an article of diet for it may be remembered that to the Indian of the Plains the " roasted dog " was a much prized delicacy. The bulk of the evidence, which is purely circumstantial, points to the conclusion that vegetables and perhaps seeds, wild berries and roots gathered from the surrounding country provided most of the Cliff Dweller's menu.

Nothing is definitely known of the identity of the vanished Cliff Dwellers. Where they came from and where they went is a mystery. The analogy afforded by so much of the remains of their material culture points to the present Indians of the New Mexican and Arizona Pueblos as their descendants, but this is largely conjectural. It is unfortunate that so little work has yet been done on the study of the human remains of the Cliff Dwellers. Since they seldom practised cremation of their dead there exists abundant skeleton material which should reveal new information of exceptional interest. The little work that has been done fulfils this prediction. Anatomically the

Cliff Dwellers are not to be sharply differentiated from the present Indians of the south-west. The antique school of philosophy that regarded the Indian as the "noble savage," perfect in every department of physical, mental, moral and spiritual existence, could not have taken the Cliff Dweller into active consideration. The coarse diet of corn with a liberal admixture of sand from the grinding stones wrought havoc with their teeth.

No written records of the Cliff Dwellers exist. The Indians never keep any form of written records, and these spectacular cliff dwellings were deserted some time before the first Spaniards entered the land in the sixteenth century.

It is possible that the reason for the situation of the buildings and their subsequent desertion was the same. It is thought that the Cliff Dwellers built their homes high up in the caves in inaccessable canyon walls as a protection from the predatory tribes that were their neighbours, and that eventually these incursions forced them to move to a less troublous region. This is a reasonable hypothesis when one recalls the nature of the Apache and the Comanche, who were an active menace throughout the south-west only forty years ago.

Recently the study of the tree rings on the beams found in the Mesa Verde ruins have allowed us to date, with considerable accuracy, the time when these trees were cut and therefore the time when these buildings were built. Professor Douglass, of the University of Arizona, is the author of this ingenious and helpful chronology and is not to be too highly praised for such a valuable contribution to archaeology. According to his calculations, based on this study, the cliff dwellings were inhabited from the ninth to the twelfth centuries A.D.

The parallel in history is striking and one which seldom enters into our conception of the Middle Ages which infrequently includes the Americas in its scope. The Mesa Verde cliff dwellings were inhabited and flourishing when Europe was astir with the excitement of the Last Crusade.

Neanderthal Man in Italy.

A FULL description of the Neanderthal skull found at Saccopastore, near Rome, in 1929, has been published by Dr. Sergio Sergi in a recent number of *L'Anthropologie*. As this is the first example of Neanderthal Man to be found in Italy, the skull itself and the conditions in which it was discovered naturally add very considerably to our knowledge of Pleistocene Man in that country. The skull is probably that of a female. Beside being the best preserved, it is also the smallest of the known Neanderthal skulls, its cranial capacity being no more than 1,200 cubic centimetres. (The capacity of the Galilee skull, also a Neanderthal, is in the neighbourhood of 1,400 c.c. and in the modern Englishman averages 1,480 c.c.) The lower jaw is missing; but in proportion to the size of the skull the face is large.

The excellent state of preservation, especially at the base, has made it possible to fix with accuracy the position of the foramen, the aperture by which the spinal column enters the skull. Relatively this is further forward than it usually appears to be in Neanderthal skulls. It is, therefore, to be concluded that while Neanderthal Man carried his head with a strong inclination forward, Roman Man, or woman, walked with head erect—as erect, in fact, as it is carried in modern man. From the large number of the small supernumerary bones, known to the anatomist as Wormian bones, which are to be seen in the occipital region—a characteristic also of other Neanderthal skulls, as seen in the La Chapelle, La Quina and Gibraltar skulls—Dr. Sergi concludes that in Neanderthal Man this region was in process of evolution. In its general character the skull most nearly approaches the Gibraltar skull. This was pointed out by Sir Arthur Keith in his "Recent Discoveries Relating to the Antiquity of Man" where he referred to the discovery of this skull; but then only a brief preliminary note on it was available.

The palaeontological data associated with the find are interesting, as they serve to fix the geological dating of the skull. With it were found remains of the great fossil mammalia of pleistocene age—the elephant (*E. Antiquus*), rhinoceros (*R. Merckii*), and hippopotamus (*H. Major*). These belong to the fluvio-lacustrine deposits, rich in volcanic elements, of the Tiber Valley, which Roman geologists hold to be contemporary with the warm interglacial period intervening between the Riss and the Würm glaciations of the European Ice Age. This is also the period to which already had been assigned the stone implements, relics of a Mousterian industry, which have been found in the alluvial deposits of the Tiber Valley. Presumably, therefore, they were the work of contemporaries of our Roman Man.

Research for the Timber Trade

By W. P. K. Findlay, B.Sc., A.R.C.S.

Forest Products Research Laboratory, Princes Risborough.

Timber in all its aspects is being studied at the Forest Products Research Laboratory, and the results of research have already proved of outstanding importance. Recent problems attacked range from finding a suitable creosote for railway sleepers to curing an epidemic of the death watch beetle in an old church roof.

ENGLAND has always been a prodigal user of timber, and during the whole of last century immense quantities were brought into this country. Only a small fraction of our requirements is grown here, for until recently forestry has not really been taken seriously and practically the whole of our supply of softwoods is imported from America and the Baltic countries.

Many Problems.

The Department of Scientific and Industrial Research has long been aware of the many unsolved problems facing the timber users of this country and in 1921 set up a Forest Products Research Board which quickly set to work. At first activities were limited to making grants for work in various Universities in connexion with particular problems, and a nucleus organization was formed in the Air Ministry premises at Farnborough. The scope of the work extended rapidly, however, and it was decided to found a fully equipped Forest Products Research Laboratory, such as already existed at Dehra Dun in India, at Montreal in Canad. and at Madison, Wisconsin, in the United States of America. Twenty-five acres of land were purchased at Princes Risborough in Buckinghamshire and in 1927 a building to house the administrative staff and a number of other buildings containing the testing laboratories, seasoning kilns and workshops were erected.

A year or two later it was decided that the research programme should not be restricted to problems immediately concerning the United Kingdom, but should include the study of woods from the Empire; a generous grant from the Empire Marketing Board enabled the Laboratory to be extended considerably and a new wing on the main block now contains the scientific sections which were formerly stationed at Oxford University and at the Imperial College of Science. Timber is studied in all its aspects and the research staff is divided into a number of sections, which are concerned with the structure, the chemistry and physics of wood and the decay and preservation of wood, as well as with the more technical problems of seasoning and testing timber and the general questions of supplies of and markets for the material.

It is frequently no easy matter to identify a timber botanically, and the section of wood structure is building up a comprehensive timber library of specimens and microscopic preparations of wood authoritatively identified. In addition to this fundamental, systematic work, a detailed study of British timbers is being undertaken and an effort is being made to link up the structure of wood with its other properties so that it may be possible to predict the properties of a timber from an examination of its structure. Close co-operation is maintained with the forestry research officers, and a study is being made of the influence of the conditions under which a tree is grown, upon the structure of the timber it produces, with a view to improving the quality of the timber produced. The rate at which a tree grows has a considerable influence upon the quality of the timber; the strongest coniferous timber is generally produced by fairly slow-grown trees, while ring-porous hardwoods are usually stronger when rapidly grown. An investigation carried out at the request of a manufacturer of tennis rackets showed that ash for rackets is at its best when the wood is grown so that there are not more than eight annual rings to the inch.

Testing the Strength.

The section devoted to timber testing is a large one and many thousands of tests are carried out upon the huge machines, some of which are capable of exerting pressures up to 200,000 lbs. to the square inch. Tests are carried out upon what are known as small "clear" specimens which are free from any defects, in order to obtain figures representative of the average strength of the species, and also upon timbers in structural sizes, as in the form of joists, which give practical if less scientific results.

When a tree is felled the wood is very wet and may contain more than its own weight of water. Timber must be dried before it is used in buildings or for

furniture because it has the peculiar property of changing its shape when it becomes dry and also becomes much stronger. Moreover, if articles are made from wet wood they warp when they become dry. It has long been the practice of timber merchants to stack timber, after it is converted, in an airy place for some considerable time before it is used. This means, however, that a large amount of capital must be locked up for long periods during which the timber is exposed to the risk of fire and deterioration. Means of drying valuable woods more rapidly than by so-called air seasoning have therefore been sought. The drying may be hastened by the artificial application of heat, but this must be done carefully to avoid damaging the timber. The wood is placed in special kilns, in which the temperature and humidity are accurately controlled. Heat is applied cautiously at first and, as drying proceeds, the temperature is gradually raised and the humidity lowered. A number of experimental kilns have been constructed for the seasoning section and a systematic study of the treatments best suited to each of the more important species of timber is being carried out. Most timbers can be kiln-seasoned satisfactorily, either from the green state or after a preliminary air-seasoning, although, of course, it may not be economic to use the process for low grade material.

AIR SEASONING.

When a tree is felled the wood may contain more than its own weight in water and must be dried before use. The photograph shows various timbers undergoing air seasoning.

Normally, wood always contains some moisture, the amount of which depends upon the dampness of the atmosphere. When wood is put into a house it should be as nearly as possible at the moisture content which it will finally attain. In order to ascertain the moisture content of wood articles in ordinary use a series of samples was kept in living rooms heated by fires, in unheated rooms, in centrally-heated offices, and so on. These were frequently weighed and from the results obtained it was possible to specify the approximate moisture content of wood used for making various types of furniture, so that the minimum amount of warping and change of shape should take place when the articles came to be used.

Drying timber also renders it less liable to decay, for the fungi which live upon and destroy wood require it to be damp before they can attack it. A great deal of quite unseasoned timber has been used in the construction of houses since the war and the amount of damage caused by the dreaded dry rot fungus has greatly increased. The problems involved in the prevention and treatment of dry rot are being studied by the mycology section and a special experimental building has been constructed for the purpose. The magnitude of the damage caused by dry rot may be gauged from the fact that the cost of the repairs which may be rendered necessary in even a small house may run into hundreds of pounds, and in some districts where numbers of houses have been built on somewhat low-lying sites the damage caused by fungal decay has, in the last few years, amounted to many thousands of pounds. Decay in dwelling houses is only part of the problem and considerable trouble is experienced in industrial buildings such as weaving sheds and cold stores.

A study of all the more important fungi which cause decay in timber is being carried out, and a large number of species is kept growing in the laboratory in culture upon malt agar jelly. It is often impossible to tell what fungus has caused damage to a piece of wood from an examination of the wood itself, but if the fungus within it is alive, it may be brought into culture and compared with the standard cultures made from named fruit bodies of fungi; it is thereby easily identified. While the mere name is in itself of no value, it is important to know the identity of the fungus, because that gives one a clue as to where the trouble originated and when infection of the timber occurred; for instance, if the fungus is one which causes a heartrot of standing trees, infection must have occurred in the forest and not in the yard of the timber merchant.

Wood is often used in positions where it is bound to become wet and will in consequence decay rapidly unless preserved in some way. For many years past practically all the wood used for railway sleepers,

telegraph poles and paving blocks in this country has been impregnated under pressure with creosote, and as long as this material is cheap and plentiful it will probably remain the standard preservative for all timber used out-of-doors, as it resists the action of the weather more effectively than any other preservative. Many timbers, however, are difficult to treat so as to ensure that the creosote really penetrates into the fibres, and methods of forcing the oil into the wood of refractory species, such as larch and Douglas fir, are being investigated by the wood preservation section. It has been found that by making shallow longitudinal slits in the wood the absorption of creosote is greatly increased, and by means of this "incising" process many timbers, difficult to treat otherwise, can be satisfactorily impregnated.

In many coal mines, where the air is warm and humid, the timber used to support the roof and sides of the "roads" decays with amazing rapidity, becoming covered with masses of snowy-white, luxuriant fungus growth, and it may in consequence have to be renewed as frequently as once a year, involving heavy expense. In this country very little of the timber used underground, even for more or less permanent work, receives any preservative treatment or "pickling," and it is certain that considerable economies could be brought about in some mines by the use of wood preservatives. To determine the most suitable preservative, and to demonstrate the effectiveness of preservative treatment, a large number of pit props treated with various antiseptics, such as zinc chloride and sodium fluoride, have been placed in damp coal mines in different parts of the country, and their "life" as compared with that of untreated props is being carefully followed. Although the experiment was only started about a year ago the untreated props are showing signs of decay while the treated ones are quite intact.

Creosote is not suitable for use in places where there is objection to its smell or where there is risk of its coming into contact with paint or plaster. Various new wood preservatives, claiming to have special properties, have been introduced; some of these are quite effective, but others are practically useless, and it is therefore important to have methods for testing their value. The standard tests which are in use fall into two classes, first, laboratory tests and secondly field and service tests. In the former, small wood blocks, treated with the antiseptic in various strengths, are exposed to severe fungus attack under controlled conditions, and the amount of fungus growth is measured by the loss in weight of the blocks resulting from decay; the less the amount of preservative required to stop all fungus growth the more efficient is the substance adjudged to be. A special room has been built for testing the efficiency of preservatives intended for use in houses or mines against dry rot fungi. Here the conditions existing in a damp coal mine or cellar have been imitated, the floor is kept covered with water and the air is warm and damp; treated and control specimens are placed upon the shelves, an infected piece of wood is nailed to each and the results are noted.

THE "GRAVEYARD."

Treated and untreated pieces of wood are planted in rows in the soil and the specimens are examined twice a year. In this way the efficiency of the preservative is tested.

In the field tests treated and untreated pieces of wood are placed in rows in the soil in a corner of the Laboratory grounds, known as the "graveyard," where the rows of little tablets, each with its metal label, suggest that the mortality among the staff is alarmingly high! The specimens are examined twice a year and the difference between the "life" of the treated specimens and of the controls gives a measure of the efficiency of the preservative. Three such "graveyards" are being laid down in different types of soil.

Fungi are not the only enemies of timber, for wood-boring insects are also responsible for much damage. Luckily we do not have in this country the omnivorous white ant, which is the chief enemy of timber in the tropics. But a recent survey of docks, timber yards and premises of wood-using industries by the entomology section of the Laboratory has shown that insect damage, especially in hardwoods, is much more extensive than was generally recognized. The serious damage to the roof of Westminster Hall by the death

watch beetle caused considerable alarm, but this was by no means an isolated instance, for many fine old church roofs are in danger as a result of the insect's activities. The study of the beetle has proved extremely difficult as it has not been possible to rear it in captivity in the laboratory; it develops very slowly and seems to need rather special conditions in the wood. The moisture content of the timber appears to be an important factor. Practical experiments on a large scale with death watch beetles are planned in the experimental building referred to above. The so-called "worm" in furniture is the larva of the furniture beetle *Anobium punctatum*, and the round holes made by the beetles when they emerge from the wood are so frequently present in old furniture that the really enterprising "faker" of period pieces reproduces them artificially! One of the most effective chemicals for dealing with furniture and death watch beetles is ortho-dichlorbenzene.

Wood-inhabiting insects appear always to prefer unsound timber containing a certain amount of fungus, and a case of definite symbiosis between an insect and a fungus has recently been studied: The wood wasp, *Sirex*, attacks unhealthy larch trees and buries its egg deep into the sound, solid wood. Dissection of the insect shows that it carries two small glands which are filled with tiny pieces of fungus, and that when an egg is laid, a piece of fungus is always present on the shell; this starts into growth in the wood and by the time the egg hatches, the wood round it is already slightly decayed. It is concluded that such "pre-digested" food is much more suitable for the young larva than sound wood.

Team Work.

The value of "team-work" in modern research has long been emphasized and especially is this true in the study of timber; an investigation recently carried out upon the effect of fungal decay upon the strength of timber was the joint work of three sections of the Laboratory. It has been found that decay so slight as to be almost imperceptible to the naked eye may seriously reduce the strength of timber, and that the rate of loss of strength is extremely rapid when conditions are favourable for fungus growth. Small test pieces after ten weeks' exposure to fungus had only twenty per cent of their original strength remaining. The specimens were analysed chemically after being tested for strength, and the results showed that the loss in strength of the timber was due chiefly to the chemical changes brought about by the fungus rather than to the physical breaking down of the wood by means of the tiny threads of fungus which penetrate the fibres.

The chemistry section is making a comprehensive study of the chemical processes involved in the decay of wood by fungi; the types of decay may be classified broadly into two classes—the white rots and the brown rots, depending upon which of the main constituents of the wood the fungus makes its chief attack. The fungi which cause brown rots live mainly upon the cellulose in the wood and their action may be compared with a mild acid hydrolysis. An interesting side line is the study of the chemistry of wood smoke, which has been undertaken at the request of the Food Investigation Board, who are investigating the problem of curing fish so that a uniform product is obtained.

Uses for Waste Wood.

Charcoal making is also receiving attention, and a portable kiln has been designed to replace the old-fashioned turf kiln, which is difficult to manage and which requires a great deal of water to extinguish. There is so much waste wood produced in the timber industry that any useful outlet for this will be of value.

Close contact is maintained between the timber producers, the timber-using industries and the Laboratory. The section of utilization is engaged in finding markets for newly-introduced timbers and new uses for woods that are already well known. Before a new timber can be successfully marketed in this country a great deal of preliminary spadework has to be done; not only has research into its durability, strength, seasoning and wood-working qualities to be carried out, but information as to the amount and the regularity of the possible sources of supply must be available before the user in this country is willing to purchase any quantity of it.

Advice is given to colonial forestry departments endeavouring to sell timber here as to the requirements and peculiarities of the markets. Often the mere choice of a name will influence the popularity of a timber; who, for instance, would proudly announce that his rooms were panelled in wawa, musharage or spotted gum? Since the name of *Liquidambar styraciflua* was changed from sweet gum to satin walnut its sales are said to have greatly increased! There is much confusion about the trade names of timbers and the same timber may be known under half-a-dozen different names; and efforts are being made to straighten out some of these muddles. The large number of inquiries received at the Laboratory range from the question of obtaining a supply of apple wood for saw handles to the identification of a piece of wood from a prehistoric building.

The Modern Theory of the Universe.

By Sir James Jeans, F.R.S.

The modern view of the solar system was discussed by Sir James Jeans in a recent lecture. The author contrasted the new theory that life must be exceedingly rare in the universe with the popular nineteenth century belief that every star in the sky was distributing light and heat to maintain life on its surrounding planets.*

If every star were suddenly to give birth to planets we should in all probability remain unaware that anything was happening. Yet the problem is of thrilling interest to science in its widest sense. The old nebular hypothesis of Laplace had pictured the stars as shrinking nebulae, which rotated faster and faster as they shrank, and threw rings of matter off their equators in the process, each of which was destined in time to condense into a planet. This cosmogony implied that the shedding of planets was a normal event in the life of a star. It led to the concept, so commonly held in the nineteenth century, that every star in the sky was a sun distributing light and heat to a retinue of worlds circling round it.

Old Theories.

As solar light and heat are the essentials for terrestrial life, it was natural to take the next step and assume that every star we saw in our telescopes was busily at work radiating energy to maintain life on its surrounding planets. And when once this step had been taken, no great violence to the probabilities seemed to be implied in taking the further step of assuming that each star had been created to this special end.

The more modern view supposes that the birth of planets is very far from being a normal event in the life of a star—it is an abnormal and exceedingly rare event. So rare is it, that even if the stars have already lived the longest lives that have ever been suggested for them—lives stretching many millions of millions of years back into the past—only a minute fraction of them can be surrounded by planets. And if they are destined to live into the future for the longest period that has ever been suggested—a period measured in hundreds of millions of millions of years—even by the end of this inconceivable length of time, only a minute fraction of stars will be surrounded by planets. This view implies that most stars must live and die without giving birth to planets at all—and, even of those that do, the majority must be so cold and shrunken before their planets are born that there can be little or no question of their sustaining life.

In brief, the older theory, with the help of a little kindly imagination, depicted a universe teeming with life. The more modern theory depicts a universe which proceeds steadfastly on its way, with life hardly coming with the picture at all. Only here and there, in insignificant corners and at infrequent intervals, a strange accident results in life stumbling into being. It can hardly be a matter of indifference to science—and still less to humanity—which picture is correct. Let me summarize the evidence which seems to me, and I think to most astronomers, to indicate that the latter is the only tenable view.

The first piece of evidence is of a purely physical nature. The action of radium, such as we see on the hands of a luminous watch, appears at first glance to be permanent, and so it is for all practical purposes; the radium which illuminates the hands of a watch will certainly outlive the clockwork which drives them. Yet careful scientific measurement shows that it is no more permanent than anything else in nature. All radium gradually loses its potency; it deteriorates, so that after about 1,600 years it will be only half as potent as it is to-day.

The reason for this loss of potency is now well understood. It is that the radium gradually changes into something which is not radium, and has not the properties of radium—the débris of radium, let us call it. After 1,600 years, a mass of pure radium becomes changed into half radium and half débris of radium. The potency of the mass is reduced to half because the amount of radium is reduced to half.

Radio-active Substances.

It follows that if we are given a mixture of radium and its débris, we can tell how long the radium has been at work to produce this débris. Substances which behave like radium are described as "radio-active." The time needed for a mass of a radioactive substance to change into half substance and half débris is known as the "half-value-period" of the substance; it varies enormously for different substances.

* *Journal of the Franklin Institute*, August, 1931.

In various rocks in the earth's crust the geologists come upon imprisoned uranium accompanied by débris of uranium. In no case is the mass of débris ever as great as the surviving mass of the uranium. There is only one possible inference—the uranium has not been imprisoned for as long as 4,500 million years. The proportion of débris found in all samples of rock tells much the same story—the uranium has been imprisoned for a time of the order of 1,500 million years. The rocks in which thorium is imprisoned have much the same thing to say—the thorium has been imprisoned for a time of the order of 1,500 million years.

Age of the Earth.

We conclude that something like 1,500 million years must have elapsed since the crust of the earth solidified. To this we must add something for the time before solidification and we shall obtain the total age of the earth. From a study of the relative abundance of ordinary uranium and its isotope actino-uranium, Rutherford has been able to show that this total age cannot have been more than about 3,400 million years.

The bodies we describe as shooting-stars confirm the story told by the earth's rocks. These objects are, of course, not true stars at all; most of them are tiny affairs, no bigger than a pea or even a grain of sand. They earn the name of stars by behaving in a dramatic way for a few seconds close at hand, but they pay for it with their lives. Dashing into our atmosphere from outer space, they are vapourized by the air-resistance they encounter, and meet their doom of being turned into a trail of luminous gas while still many miles above the surface of the earth. Occasionally one is too large to be completely vapourized by the resistance of the air, and what is left of it strikes the earth in the form of a large rock or stone known as a "meteorite." Many of these bodies are found to contain imprisoned thorium or uranium, together with the débris of their disintegration. The amount of the latter makes it possible to estimate the length of time since the stone solidified. The time cannot be estimated with great accuracy, but no body that has been examined has suggested a period of more than 2,900 million years since solidification, and the majority appeared to be of about the same age as the earth. In a general way we may say that the length of time which has elapsed since the planets and other members of the solar system solidified can hardly have been more than about 3,000 million years.

This estimate depends solely on recent advances in physical science. The earlier cosmogonists had no means of forming such an estimate, and it would have been of little use to them if they had. It is important for us of to-day, because we can combine it with recent astronomical knowledge. We can tell how much the sun and stars have changed in 3,000 million years. The sun is radiating its substance away at the rate of 360,000 million tons a day. This sounds like a very rapid loss of weight until we compare it with the huge total weight of the sun. We then find that radiation at this rate for 3,000 million years can hardly affect the sun's weight at all. The weight of the sun, and indeed of all the stars, must have been very much the same 3,000 million years ago as to-day. Further, we know from recent astronomical research that the physical state of a star depends mainly, and indeed almost entirely, on its weight. All stars which have approximately the same weight as the sun are found to have also approximately the same physical constitution as the sun. Thus we must suppose that when the planets and meteors were born, the sun not only had the same weight, but also the same physical constitution and size, as it has to-day.

This conclusion, based on evidence which can hardly be challenged, provides a test which we may apply to the various theories of the origin of the solar system in turn. It would be an impossible task to test all the theories of the earth's origin. They fall into two distinct classes, according as they suppose that the sun alone was concerned in the process of creating the planets, or that other bodies were concerned in addition to the sun.

Life Exceedingly Rare.

Stars are very rare objects in space, and so are very far apart from one another; so far apart that it is hard to imagine their sparseness in space. If only three particles of dust are left in a room, it is incomparably more crowded with dust than space is with stars. As a consequence stars approach one another very rarely; and it is an almost inconceivably rare event for two stars to come so close that planets are born. Planets, and so presumably life also, must be exceedingly rare in the universe. We can regard this with satisfaction or the reverse, as we choose. So long as we thought of each star as the centre of a system which teemed with life, human life was a very small thing; it formed an inconceivably small fraction of the total life of the universe. The new view compels us to think of human life on earth as forming a comparatively large fraction of all the life of the universe.

How the Spider Protects Itself.

By Major R. W. G. Hingston.

There are many familiar examples of natural camouflage, but less is known of the ingenious protective devices which certain insects themselves construct. The author has made a close study of artificial concealment among spiders and describes for the first time his recent discoveries in British Guiana.

It is, of course, a matter of common knowledge that many animals, especially insects, escape their enemies through blending with their environments. Every naturalist can quote numerous examples in all degrees of complexity and perfection. We have stick-insects and leaf-insects astonishing in their similitudes, butterflies the image of decayed foliage, caterpillars twisted into the shape of snail-shells, membracids exactly like vegetable thorns, moths coloured like the excrement of birds. Then there are the many examples of mimicry where a defenceless group of insects escapes destruction by being mistaken for one better protected.

"Passive" Concealment.

There is one feature common to all, namely, that the animal has been passive in the process. It has taken no part in devising its concealment. The stick-insect, for example, lives in sticky surroundings, but it has taken no part in fashioning them. Nature has made it stick-like and has given it a stick-like environment in which to live. It is the same with almost all of these insect devices. Nature has made the animal of a particular colour, size or shape; and its colour, size or shape fits in with something in the environment that matches it.

But there are certain equally remarkable instances which we might well call "concealment by design." In these cases the creatures make the objects that conceal them; they do not just blend with what nature provides. They manufacture the camouflage specially for themselves just as definitely and with the same purpose as does man when he camouflages his ocean-going ships in order to conceal them during times of war.

Of this remarkable capacity for artificial concealment I have met with only a few examples among insects. The best was that of a small caterpillar which occurs in the forests of British Guiana. It was probably the larva of *Siderone marthesia*. I found it in the darkest part of the forest on a plant with long pointed leaves belonging to the genus *Pithecollobium*. The leaf on which the caterpillar rested was ten and a half inches long, but the caterpillar had eaten away the apex until nothing was left but the bare midrib for a distance of three and three quarter inches. Having bared the midrib, it had cut off five small pieces of leaf and anchored them to it by a few threads. The pieces were somewhat elongated, roughly quadrilateral, and approximately about the same size as the caterpillar. They were green and fresh and had obviously been recently cut. The caterpillar had seated itself on the bare midrib half an inch from the extreme tip. Its dorsal surface was light green; its sides paler and almost white. The effect of this shading was to give it a dull green appearance and exactly the same tint as that of the attached pieces of leaf. The device concealed it perfectly. The caterpillar was just an odd piece of leaf among other pieces on a bare midrib.

I came across a second example which showed how the development of the caterpillar fitted in with the withering of the pieces of leaf. In this example the caterpillar was much larger. It was seated near the end of the bare midrib exactly as in the first example, but the leaf had been much more eaten and its outline was very ragged. The interesting point about it was that the piece of leaf attached to the midrib had withered into a rich dark brown colour, almost but not quite black. The caterpillar had itself changed from the green colour of its earlier stage to exactly the same brown colour of the withered leaf. The caterpillar is first dull green in order to match the freshly cut pieces; later it moults into a withered dress in order to match the withered leaves.

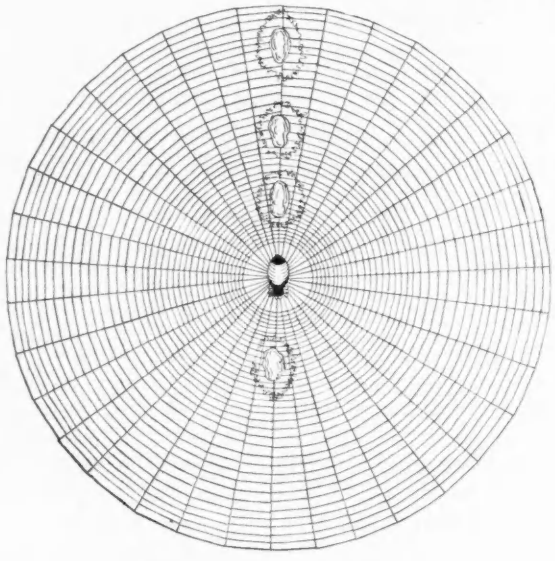
Disguised as a Leaf.

Here then we have an example of an insect making an artificial protective disguise. It secures by its operations most efficient protection. For some reason a great number of the forest leaves, especially in swampy areas where this caterpillar lives, have their extreme tips withered, crumpled and black. In some places quite one-quarter of the leaves have undergone this change. And the brown-black caterpillar

with its brown-black pieces of leaf combine to make a withered leaf-tip just like the crowds of other leaves which grow everywhere in the swamp.

But there is another large community of animals, hitherto greatly neglected, which illustrates the plan of artificial concealment far more strikingly than any insect. These creatures are the orb-weaving spiders whose remarkable activities in this direction have surprised me in all parts of the tropics. I will here mention a few examples which I have encountered in the equatorial regions of Asia and America.

Certain spiders belonging to the genus *Cyclosa* conceal themselves in a string of pellets. The spider makes a cartwheel snare of the usual geometrical pattern. It seats itself fully exposed at the centre and constructs a string of small pellets along one of the diameters of its snare. One species which is common in the western Himalaya usually makes from six to ten pellets from fragments of captured insects intermingled and fastened together with silk. They are fairly uniform in size, oval or spherical, and brownish-white in colour; the spider closely resembles them. It is roughly of the same size and shape, also the same brown-white colour. When sitting on the snare it tucks its legs underneath it which has the effect of making it globular and exactly pellet-like in appearance. The spider always sits in line with its pellets. As a result it is perfectly hidden. One cannot tell the spider from its pellets unless one knows the fact beforehand that it always sits at the snare centre.



A SPIDER WHICH CHANGES COLOUR.

When the leaf is touched, the spider throws its body into a rapid vibration, its colours become fused, and the insect is thus indistinguishable from the pellets.

Obviously this is an artificial concealment. The enemies of these spiders are solitary wasps which carry them off to their mud cells. In the tropics one sees the wasps searching everywhere and one is continually coming across their mud nests stuffed tight with numbers of spiders. There can be little doubt that when a wasp arrives and is about to pluck the spider from the web it is confused by the string of pellets. It is for the moment puzzled and cannot tell which of them is the spider. In the end it makes a dart, but is just as likely to strike a pellet as the spider, and the moment it touches one of the pellets the spider instantaneously lets go its hold and escapes by dropping to earth. We must, therefore, regard the pellets as a kind of artificial decoy. They lure the enemy away from the spider, whose chances of escape will be in proportion to the number of its decoys. No doubt the number of pellets it makes will depend on the number of insects it catches since the pellets are made largely out of their remains. Hence abundance of food means not only better feeding, but greater protection from the enemies that abound.

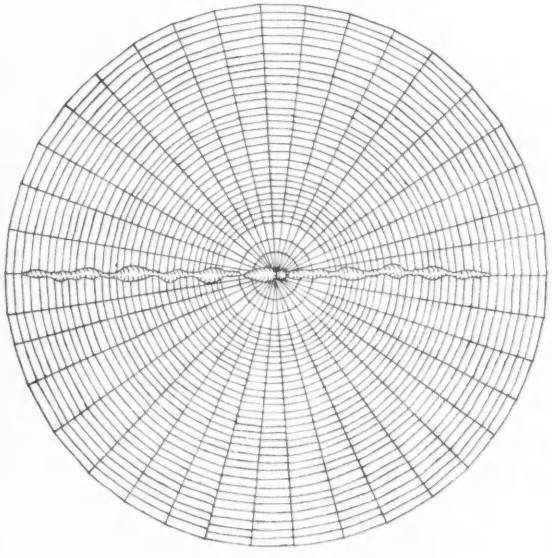
I have met with many examples of the pellet device in the tropics of Africa, Asia and America. There are several modifications of the main principle which differ in matters of detail. But one always finds it the general rule that the spider very closely resembles its pellet. To this rule I have met with only one exception. The spider *Cyclosa tremula* lives in the Guiana forest. It is very small, only one-twelfth of an inch long. In colour it is conspicuously black and white, the cephalothorax being deep brown and almost black, the abdomen white in the middle with a black transverse band in front and a black triangular patch behind. We have here a striking exception to the rule that these spiders always blend with their pellets. The exception must be capable of some explanation, otherwise the theory of protection breaks down.

I found the snare among leaves by the side of a forest trail. The spider sat in the centre, head downwards, with its long axis in the vertical diameter of the orb. In the same diameter it had placed four grey pellets, three along the upper radius and one on the lower radius. The pellets were the same size and shape as itself, and had they been of the same colour, the protective significance would have been apparent at a glance. They were fixed at regular intervals from

one another and at about an equal distance from the spider at the centre. Thus the spider was one black and white pellet in an evenly distributed string of five.

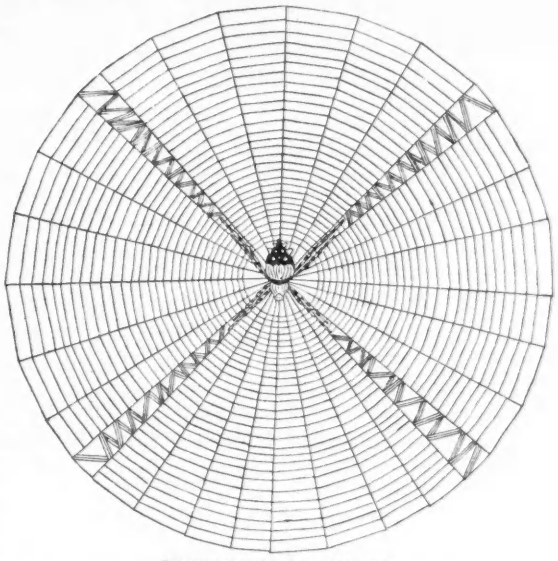
The sharp difference between spider and pellet, though at first-sight undermining the principle of protection, turns out to be the exception that proves the rule. The spider is black and white, the pellet is brown. But the moment I touched the leaf to which the snare was anchored the spider immediately underwent a transformation. It raised itself a little from the snare, then threw its body into an extremely rapid and delicate vibration which had the result of changing its colour. What must happen is that, as a result of the rapid quivering, the black and white patches on the spider's body come to occupy alternately each other's place. As a consequence the white and black colours become fused to the eye and the spider appears exactly the same colour as the pellets. We have, therefore, a delightful illustration not only of a spider making a special concealing device, but, by its movements, altering its colour in order to blend with the colour of that device.

Another device—concealment by bands—is made by *Cyclosa caroli*, a small slender elongated spider one-quarter of an inch long. I found it both in Trinidad and British Guiana. The snare was spread in low vegetation about four feet above the ground. Across the horizontal diameter of the orb for about two-thirds of its width was a distinct grey or yellow-grey band. The band was composed chiefly of silk, but mixed with it were many bits of insect fragments. On it were a number of constrictions which gave it something of a beaded appearance. In the middle of the band was a gap which the spider filled with its own body. It aligned itself horizontally in the gap so that its long axis became continuous with the band. It was exactly the same grey colour as the band, and its breadth was equal to the width of the band. The result was that the spider appeared to be part of the band, and indeed was completely hidden. There is no exaggeration in the statement that one could not pick out the spider from the band unless one was acquainted with the fact that it always sat in the snare centre.



THE BAND DEVICE.

Across the horizontal diameter of the orb is a grey band composed chiefly of silk. The spider sits in the centre and appears to be part of the band.



CONCEALMENT BY ZIGZAGS.

Concealment by zigzags is common among many spiders. The species shown devises a St. Andrew's cross arrangement, of which the spider forms the centre.

This plan of making a diametrical concealing band occurs all through the tropics. I have seen it in Trinidad, South America, Barbados, Grenada, St. Lucia, Central Africa, India, Mesopotamia. It has also been observed in the United States. Many different species adopt it. In all instances they stretch themselves in line with the band; their length just fits the gap in the band, the widths of their bodies equal the widths of the bands, and their colours and the colours of the bands match. Each of these details is essential if perfect harmony is to be secured. And when we find a number of different species, though unlike one another in other particulars, yet all resembling in these small details, we can scarcely contend that the diametrical bands have any other purpose than to conceal the spider.

The making of zigzags is another of these devices. The species here described, *Argiope argentata*, arranges them like a St. Andrew's Cross. It is a fairly large, brilliantly coloured spider with a triangular abdomen margined with blunt teeth. The front half of the abdomen is closely covered with silvery hairs which give it a vivid metallic lustre. The thorax is silvery but not so shining. The hind half of the abdomen has some silver markings but in the main is reddish brown. I met with it in Trinidad, Grenada, St. Lucia and on the Guiana mainland. Its snare is about six inches in diameter and has in it a device of four ribbons arranged in the form of a cross. The ribbons are very conspicuous, being bright silvery angulated structures much thicker than the ordinary snare lines. Each zigzag arm has forty to fifty angles. It is fixed tightly between a pair of radii and has a tendency to draw these radii together. The arms occupy about one-half the width of the orb and give an elegant appearance to the web, their silvery appearance contrasting sharply with the transparent radii and spirals.

The spider sits head-downward at the snare centre. Its legs are spread around it in pairs, one pair in line with each arm of the cross. This position and attitude is unalterable. Legs are always kept in line with ribbons. Thus the spider, together with its ribbons, makes one large conspicuous cross. The silvery colour of the spider blends with the silver ribbons, and the angulations of its body fits in with the angulations of the zigzags.

The great value of the zigzag arrangement is indicated by the quantity of silk required to make it. The spider would not expend all that precious material were it not to some valuable end. The zigzags protect the spider in two ways, partly through their blending influence and partly by confusing the enemy's attack. The spider is concealed by becoming part of a cross. The bright silvery angulations absorb attention; they draw the enemy away from the spider and distract it by their multitude of points. It has been thought that these zigzag bands and braces serve the purpose of strengthening the snare, but I feel certain that their real object is to hide the spider and thus to confuse its foes.

An Artificial Flower.

Other silvery spiders of the same genus arrange their zigzags in a different manner. One species, *Argiope clarki*, which I met with in Baghdad, makes a line of zigzags across one diameter of the snare and seats itself in the middle so as to complete the line. In fact it acts like the spider in the band device, except that it works with a silvery zigzag instead of a grey nodular band. There is another species, *Argiope catenulata* of Burma, which makes three lines of zigzags that radiate from the snare centre. The spider takes its seat in the middle and stretches out its legs in such a way as to complete the triradiate structure. Other species, instead of placing their zigzags in lines, mass them round the central area of the snare in what looks like a brilliant silvery flower. In these examples the spider sits on the flower and its silvery colour blends with the zigzags. By making these peculiar silvery devices the spider is putting into its snare something which is highly conspicuous. It is so vivid that it catches the eye immediately. So we have what at first seems to be a paradox; a structure is made to attract attention and yet that structure is intended for concealment. It is really a kind of hiding by advertisement.

How Zigzags are Made.

The making of the zigzags can occasionally be witnessed. It is done after the ordinary web-lines have been finished. The spider, having completed its radii and spirals, starts another kind of thread expulsion. Instead of emitting single filaments, it gives out from its spinnerets a thick sheaf of threads that looks like a white flocculent ribbon. It gets in between two radii, say A and B, and works from within towards the circumference of the orb. It begins by attaching the ribbon to A, then lifts its abdomen, carries the sheaf of filaments across between the radii, and makes its second attachment to B. As it swings across it moves forward a little, and as a consequence of this forward movement its second attachment is a little further out than its first, and the ribbon between A and B is given an oblique course. Then the spider swings back again, advances a little as before and makes its third attachment to A. In this way it keeps swinging and advancing outward between the radii and fixing its ribbon alternately to A and B. The result is a zigzag ribbon extended between the two radii across the orb.

I believe that these various web contrivances have been developed in order to hide the spider and give it a momentary chance of escape. They are essentially artificial, being exclusively the handiwork of spider. When we consider their peculiar and elaborate nature, the amount of labour involved in their manufacture, all the expenditure of precious silk, and the wonderful elaboration of the instinct that has been developed we can get some dim idea of the struggle that these litt.e creatures have to face in order to survive in the battle for life.

The Progress of Archaeology.

Important excavations are proceeding in various parts of the world, but space does not permit full-length accounts of all. These notes briefly review progress in archaeological work not already described in DISCOVERY.

EXCAVATIONS on Roman sites in Britain are now once more in full work. Dr. Mortimer Wheeler has resumed at the site of Verulamium, St. Albans, after a preliminary reconnaissance in July which occupied two weeks. This season's work will last for two months or a little longer. The principal area of excavation, it is announced, will be in the centre of the southern half of the city, where it is hoped to uncover a complete block (insula) with its flanking streets. Excavations will also be made in the early Roman earthwork, which is apparently a small fortification erected after the destruction of the city by Queen Boudicca, and in the prehistoric city which was abandoned when the first Roman city was built. Excavations have also been in progress during the summer at Housesteads where the *vicus* round the fort of Borovicum on Hadrian's Wall is being explored. This work is being carried on by the Durham University Excavation Committee. Three stone buildings outside the southern gate are being examined, and finds of pottery and coins indicate that they were built under Severus and reconstructed at the beginning of the fourth century A.D. An interesting discovery of two inscriptions points to the existence of a corporate life in the *vicus* and the survival of traditional religious cults in the midst of alien creeds.

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Objects found by Dr. Campbell-Thompson's expedition of archaeological exploration at Nineveh (Kuyunjik) are now temporarily exhibited in the Nimrud gallery of the British Museum. Thanks to the generous assistance of Sir Charles Hyde this expedition has now completed its third season's work. The site of the past season's excavations was found to have been much disturbed by building and plundering, and the finds are of an extremely heterogeneous nature, ranging in date from the Christian era to about 3,000 B.C. The most notable discovery was a life-size bronze head of a man, dating from about the early part of the third millenium B.C., which in certain details suggested affinities with the gold helmet found at Ur belonging to the First Dynasty. This has been retained for the Baghdad Museum and is represented here by photographs only. An important inscription of Shamsi Adad (1850 B.C.) records that he had disturbed at Nineveh a build of Manishtusu (2500 B.C.), second son and successor of Sargon the Great of Akkad. We thus learn for the first time that the widely extended conquests of that great monarch had secured some permanence of influence in Nineveh for his successors.

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Mr. Guy Brunton's exhibition of objects found during the last season's excavations of his expedition to Middle Egypt, also in the Nimrud Gallery of the British Museum, again proves to be of considerable archaeological significance, especially in regard to relics from the Tasian, Badarian and Amratian cultures of the early predynastic period. Of these the two earlier are dated at about 5500 B.C., and the later, Amratian, at about 4500 B.C. Especially noteworthy were the Amratian slate-palettes in the form of turtles, fish, birds and an antelope, and the ivory anthropomorphic amulets. A fine Amratian bowl in unpolished red-painted ware showed a crocodile and five small hippopotami moulded on the rim. Objects from the earlier Badarian and Tasian cultures included well-preserved examples of the delicate black "ripple" ware.

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Exploration of the caves of the Wady-el-Mughara in Palestine conducted by Miss Dorothy Garrod on behalf of the British School of Archaeology in Palestine during the past season has again produced material of importance in its bearing on early man and his culture in that country. Among the more significant finds must be counted a skull and lower jaw of a child found by Mr. Ted McCown in association with a Mousterian industry in the cave Mugharet-el-School. As it is suspected that the block of breccia in which they occur may also contain the skeleton, it will be forwarded whole to Sir Arthur Keith for examination. At Mugharet-el-Kabara Mr. Turville Petre has obtained from a mesolithic horizon bone sickle-blade hafts with animal heads carved at the top, many bone harpoons and various pieces of carved bone and stone. It is hoped that some of these may be available for exhibition in England later. Miss Garrod herself has been engaged in excavating a series of mesolithic burials at Mugharet-el-Wad, the largest of the Wady-el-Mughara caves. In these burials circlets and necklaces of bone and shell are found still in place.

On the best preserved skeleton, which has been removed to the Palestine Museum in a solid block as it was found, a cap strung with dentalia shells was still round the skull, and the lower jaw is full of bone pendant beads. Illustrations of the skeleton and a brief report by Miss Garrod appear in *Man* for August.

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In the course of a successful season's work at Jerash, the joint expedition to Palestine of Yale University and the American School of Oriental Research has cleared the well-preserved pavement of a forum surrounded by a pillared colonnade and the walls of shops belonging to the Roman period, dating probably from the first century of the Christian era. Beneath this forum, at some depth, excavation revealed the first evidence to be found of the Hellenistic city in the shape of buildings and a fine gateway. South of the city was a circus of considerable size. An interesting discovery was made a mile and a half north of the city on the site of a spring and a large pool constructed of stone masonry. Behind the pool is a theatre situated above colonnaded terraces. This is shown by an inscription to have been the place of celebration of the festival of Maiumas. The theatre is unique and its further examination will, no doubt, reveal more of the nature of the festival, of which little is known, except that it was a species of water saturnalia which was suppressed on several occasions by the Roman emperors on the ground of its obscenity.

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Sir Arthur Evans' two communications to *The Times*, dealing with the Temple Tomb of the Priest Kings of Knossos, embodied some remarkable conclusions at which he has arrived as the result of further research into the structure and contents of this unique monument. This he regards as the most important of his discoveries apart from the Palace of Minos. The Tomb was, it would appear, the centre of a cult of the Royal dead under the keeping of the Minoan mother-goddess. The foundation of the temple goes back to the first quarter of the sixteenth century B.C. It suffered much damage from earthquake about 1520 B.C. and became merely a cenotaph until the cult was revived with the reopening of the Tomb for Royal burials in the last Minoan epoch. The further discovery of a dwelling in relation with the Tomb by a paved way, probably the residence of its guardian priest, is in some ways even more interesting on account of its unique character. This High Priest's House has as its most noteworthy feature a hall, with inner sanctuary and altar, which distinguishes it from all known Minoan houses. It is the first to be discovered in which there is a hall set aside for religious services.

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The discovery of a prehistoric boat or dug-out canoe in the Isle of Man, announced by Mr. W. Cubbin in *The Times* of 5th August, presents many points of interest, especially in the light it throws on the technique of boat-making employed by early man in Britain. Almost as remarkable is the situation in which it was found. For it is evident that there is here a workshop, as is shown by the floor of packed earth and white stones, as well as the oak twigs and "chips," immediately adjacent to a "holy well" which must have been previously the site of a pagan religious cult, if, that is, we may judge from the analogy of other holy wells. In the description of the boat it is indicated that it differs in several points from other prehistoric boats found in Scotland and Ireland in the absence of the pointed prow, the irregularly shaped stern, and in the fact that the bottom is not flat, but shows the original rounded form of the oak tree-trunk, although a small space immediately under the stern has been flattened by careful workmanship. It is possible, however, that these differences may be due to its unfinished state. Such boats discovered elsewhere in the British Isles have been attributed to the Bronze Age and there seems no reason why this newly-discovered example should not be of the same date. No tools have as yet been found, with the exception of a group of chisel-shaped implements of white quartzite.

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A description of a collection of stone implements from Mazeppa Bay in Cape Province has recently been submitted to the Royal Society of South Africa by Mr. C. Van Riet Lowe. It deals with an industry not hitherto recorded in South Africa. As it consists entirely of surface finds, any conclusion as to its archaeological horizon is necessarily based on technique. This assigns it to the Middle Stone Age, but it is probably late and may even belong to the early Late Stone Age. The industry was practised over an area of approximately twenty thousand square miles, and the implements include a type for which the name "Giant Crescent" is suggested on account of its form. Only one such implement was known previously in South Africa. Mr. Lowe points out a remarkable parallel. In Europe implements of this type belong to a transition period from Mousterian to Aurignacian and exactly the same characteristic is to be observed in South Africa. The industry with which the implement is associated probably represents an analogous transition.

The Greatest Water Power in the World.

By Edward C. Rashleigh.

Special interest attaches to this first-hand account of a recent visit to the Guayra waterfalls on the Parana river as little reliable information has hitherto been published. It is not perhaps generally realized that these falls have more than twice the volume of Niagara and ten times that of Labrador.

SOUTH AMERICA boasts three of the greatest waterfalls in the world : Paulo Affonso on the Rio São Francisco, Guayra on the Alto Parana and those on the Iguazu, one of the Parana's numerous tributaries. If I do not also include the celebrated falls of Kaieteur, in British Guiana, which far exceed in height either of the above three, it is because their much smaller volume scarcely entitles them to rank in the same category. Quite obviously, the really great falls of the world can occur only on great rivers. In assessing their various magnitudes it is volume, granted of course a certain height, which should be regarded as the principal factor, mere width or extent being a secondary consideration.

Sixteenth Century Visitors.

Though still far less known than most other great falls, it is not improbable that Guayra was the first to be seen by Europeans. As early as 1527 Gaboto ascended the Parana as far as the rapids below the falls, and some claim that he actually saw them. It seems at any rate fairly certain that Melgarejo and his companions must have seen them about 1554, when the former founded the town of Ciudad Real not far from the falls ; it was, later, so destroyed by the Paulistas that scarcely a trace of it now remains. The Iguazu falls were first seen by Alvar Nuñez and his men during their memorable four months' march of two thousand miles from Santa Catalina on the Brazilian coast to Ascuncion in 1541-2 ; while as for Paulo Affonso, records are silent, but it was undoubtedly visited at least earlier than 1589. Thus all three South American falls were known before Niagara, it being probable that the first European to see the latter was Etienne Brulé, Champlain's interpreter, who was in that neighbourhood about 1615, more than eighty years before Father Hennepin wrote his account in 1697.

The best known of the early accounts of Guayra is that of Felix de Azara who visited it in the closing years of the eighteenth century. After stating that the cataract was formerly known as the Fall of Canendiyú, from the name of a Cacique who lived nearby at the time of the Conquest, de Azara writes, " It is a frightful cascade and worthy of being immortalized by the poets. It occurs on the Parana River ; that river which, lower down, is called the La Plata and which, even in this part of its course, has more volume than a multitude of the greatest rivers of Europe combined, having in its normal state, at the very point where it takes its plunge, immense depth and a width of 2,100 toises, equal almost to a marine league. This enormous width is suddenly contracted to a single channel of no more than thirty toises wide, into which the whole mass of the water enters, falling with astounding fury. One would suppose that this river, exulting in its volume and in the velocity of its waters, the most considerable in the world, desired to shake the earth to its very centre and to bring about the oscillation of its axis.

" The waters do not fall vertically or straight down but on a plane at an inclination of fifty degrees, so as to give a perpendicular height of fifty-two Parisian feet. The dew or vapour which ascends where the water strikes against its rocky walls and against the projecting boulders which occur in the channel of its descent, are seen at a distance of several leagues in the form of columns ; and near at hand in the sun's rays they form different rainbows of the most vivid colours, in which one may perceive a continual tremor. Moreover the vapours cause a perpetual rain in the neighbourhood. The noise can be heard at six leagues' distance."

A Recent Re-discovery.

Thundering down in lonely majesty in the heart of the primeval forest, and except for an occasional visitor from the outside world over long intervals of years, beheld only by the wild Guarani Indians, Guayra may be said to have been re-discovered during the last decade. To-day, the 565 miles from São Paulo to Porto Tibiriça on the left bank of the Parana can be traversed on the Sorocabana railway in less than twenty-four hours ; whence one can proceed by steamer to the township of Guayra, 220 miles downstream and just above the falls. But it will no doubt

THE FIRST FALL.
A striking view of the first fall upstream on the Paraguayan side.

be by air that the traveller of the near future will visit Guayra.

It is in their immense volume that the falls of Guayra incomparably exceed all others. Already at the falls of Urubu-punga, "The gorge of shining waters" 375 miles above Guayra, the Alto Parana has a mean flow of over 97,000 cubic feet per second, and between Urubu-punga and Guayra it receives a great number of large and small tributaries which supply four-fifths of its total volume. Thus by the time it reaches the lake-like expanse, about four miles in length and three in width, which it has formed above Guayra falls, the river has more than quadrupled its flow. Mr. Sidwell, the manager of the Matte Larangeira Company, who has resided at the falls for many years and has made a special study of them, has kindly given me some interesting statistics. He tells me that in 1920 a gauge was established above the falls on which the lowest water-level known up to that date was marked as zero. Yet at a period when the level was between only twenty to thirty centimetres above the zero mark, a Commission of the Brazilian Government, who spent a considerable time measuring the flow in 1921, found it to be no less than 406,000 cubic feet per second. Since the average high-water level reads between 2 and 2.30 metres on the gauge, with an exceptional flood of 3.5 metres, it would seem that the mean annual discharge cannot be less than about 500,000 cubic feet per second, while the flood flow may be anything from 1,000,000 upwards.

It is interesting to compare this volume with that of the following five falls which are usually considered to be among the world's greatest. The figures represent the mean annual flow in cubic feet per second : Niagara, 212,200 ; Paulo Affonso, 100,000 ; Iguazu Falls, 61,660 ; Grand Falls, Labrador, 50,000 ; and Victoria Falls, 38,430. Even the minimum flow of Paulo Affonso is usually calculated to be from 60,000 to 75,000 cubic feet per second, but the flood flow is probably five times as much. The most wild exaggerations have been made as regards the volume of the Iguazu Falls. At the same time, the rainfall in the heavily forested Iguazu basin is more than double that of the upper Zambesi. Also, there is but slight evaporation. An exhaustive report published by the Argentine Government in 1928 gives the low water flow as being from 7,381 to 8,405 cubic feet per second, and the medium flow as between 54,385 and 69,605. An observed flood figure is given as 167,498 cubic feet per second ; but it is stated that an extremely high flood may probably attain to over 450,000, which seems unexpectedly great. The estimate for the Grand falls is approximate and is not based on actual measurements. The minimum flow of the Victoria falls at dead low water may be less than 10,000. The flood flow varies greatly, but its average, taken over eighteen years, has been found to be 82,000. As will be seen, the average discharge of Guayra far exceeds that of all the other falls combined. The Commission referred to estimated its horse-power at 6,000,000 ; but it has been calculated that if it were possible to canalize and divert the whole river so as to utilize the total drop of 373 feet, the horse-power in the flood season would amount to no less than 174,000,000.

As in the case of the Niagara river, which has a total drop of 316 feet in the 36 miles between lakes Erie and Ontario, the 373 feet drop from upper to lower river at Guayra extends, according to Mr. Sidwell, over the 30 miles to Puerto Mendez. He is of the opinion, however, that much the greater part of it occurs near the actual falls. While no individual

AT LOW WATER.
It is only possible to photograph the fourth fall at time of low water.

fall would appear to exceed 130 feet, and no continuously sheer leap is over 65 feet—as far as measurements are yet known—the immense mass and speed of the water amply make up for lack of height. Indeed, even the figures quoted are still further reduced in high flood owing to the piling up of the water in the narrow gorge below the falls, from which it is unable to escape quickly enough; and there have been exceptional floods when the whole series of cataracts have been turned into stupendous rapids.

The alternative name of Sete Quedas, or the Seven Falls, by which Guayra is sometimes known, is misleading. There are at least eighteen separate falls. Immediately above the point where they commence the Parana is about 2½ miles wide, but the gorge itself has an average width of no more than eighty yards. Apart from the fall at the head of the gorge, there are five on the Paraguayan side and twelve on the Brazilian. Nearly all the falls pour into subsidiary gorges which slope steeply to the main channel; the impact of the meeting waters causing gigantic waves which are hurled twenty feet high in clouds of spray, and whose echo has been compared with the report of distant cannon.

The falls on the Brazilian side carry by far the most water. Consequently one has to cross by launch to the Paraguayan bank to obtain the finest views. Even then one must go provided with poles, rope-soled shoes and bathing attire to see properly the head fall at the top of the gorge. Major Hills and Miss Ianthe Dunbar in their book, "The Golden River," have well described how they accomplished it, wading out into the river often more than waist-deep and nearly carried off their feet, till at length they reached a rock half-way down one of the lesser falls, overlooking the main chasm.

PART OF THE MAIN GORGE.
The annual flow is estimated at not less than 500,000 cubic feet per second.

SIX MILLION HORSE POWER.
This view of the seventeenth fall gives some idea of the volume of Guayra.

"Below," they write, "were the great rapids. The river poured in thunder through the opening. One cannot compare it with water at all. It was a substance compacted of air and liquid and yet there was nothing light or airy about it. The rush and drive of it had hammered it into a solidity; and yet it had not that sameness of outline, that moving solidity, which is given by the unchanging movement of a great waterfall: for it was always changing, tossed and twisted now into this shape and now into that. At the head of the rapids stands a high rocky island, the safe fortress of many a macaw. Below the island the waters unite and rush down the widening gorge, with waterfalls on either side. As far as the eye can see are these waterfalls, thundering down, clouded with spray at the base . . . One looked at something earlier than man and untouched through time."

Neither Niagara, the Victoria falls, nor those of the Iguazu convey so arresting an impression of power as does Guayra. Perhaps the latter's most formidable rival is Paulo Affonso which, with a total height of 265 feet, the last leap alone being 192 feet at normal flow, has the advantage that its whole volume is compressed into a width of no more than 56 feet at the brink of the main fall. This immense mass, rivalling that of Niagara during the flood season, then plunges down in a dense column with such velocity that it creates at its crest a kind of "tour-billon," or whirlwind, against which it is said that no one can cast a stone for a greater distance than about eighteen feet.

Five miles above the falls the river averages a mile and a quarter in width, the usual flood rise at this point being thirteen feet. This involves an equivalent rise of no less than ninety-eight feet in the narrow gorge below the cataract.

Fighting Agricultural Pests.

By J. G. Myers, Sc.D., F.E.S.
Farnham House Laboratory.

It has been estimated that no less than one-tenth of the human effort expended on agriculture within the British Empire is dissipated by insects. In a report just issued by the Imperial Institute of Entomology, Dr. Myers describes the work which is being done to control insect pests by biological means in the West Indies.

THE main object of the mission to the West Indies was to study the possibility of biological control for the main pests of agriculture in the British Colonies of tropical America. Wherever possible, actual introductions of parasites have been made, and in addition, local Governments, planters' organizations and individual planters requested and were given advice on agricultural problems connected with entomology. The procedure has been briefly as follows: to collect general ecological and agricultural data on the regions visited with a view to collating them with the incidence of pests; to obtain a notion of the status of each pest; to discover by dissection, rearing and field observation its natural parasitic and predacious enemies, and to ascertain the average mortality caused by each; to study the life-history and ecological requirements of the several natural enemies with a view to their possible utilization; and to see whether any other natural or artificial (*e.g.*, agricultural) limiting factors are operating. In the course of the work, 28,424 dissections and examinations have been made.

Selecting Parasites.

The chief factor in deciding what parasites were most suitable for introduction into a given region has been personal judgment, influenced strongly by the record of the parasite's actual work under general ecological and agricultural conditions similar to those of the region of importation. These two latter criteria may not hold in every case, but they are the only quantitative ones available, and without them the procedure would be unnecessarily hit-and-miss. One would, for instance, unhesitatingly condemn an attempt to introduce a parasite, however efficient, from a temperate region into the tropics, unless and until the possibilities of tropical parasites had been exhausted.

Biological control has now achieved so many successes under varying conditions as to yield a considerable body of data extremely valuable for he tguidance of future attempts. Thus every success of any note, so far, has been won by the introduction of parasites into countries where they did not occur. It is therefore sound to explore fully the possibilities of this method before considering, for instance, the utilization of indigenous parasites by mass production or local distribution. Any attempts in the latter direction should be regarded simply and solely as experiments.

The Chief Pests.

It was obviously necessary for the investigator to limit his attention to the more important pests, and even there to concentrate on a few main ones rather than dissipate his energies over a wider field. An endeavour was made to investigate at least one main pest for each of the chief colonies, and where possible this was chosen in the light of requests actually made by the Government concerned. Thus banana-borer was put on the list for Jamaica, coffee leafminer for St. Lucia, and arrowroot worm for St. Vincent. None of these is really important elsewhere in the British West Indies. Emphasis must be laid on plant ecological considerations in biological control work. This is not a new factor, for extensive studies on these lines have been made by other workers engaged on corn-borer parasite investigations in Europe. It has led in the present mission to two more or less new theoretical considerations which it is believed will be of paramount importance in future practical work, at least in this area.

The first is a modification of the general view that islands, by reason largely of their limited fauna, offer more promising conditions for biological control than do continental areas. This belief has arisen largely from comparing results of attempts made on the one hand in tropical islands and on the other in temperate continental regions such as North America. The comparison is thus unfair at the base, for the relative importance of natural enemies as against climatic factors is undoubtedly much less as we increase our distance from the Equator, until at the Poles the exceeding paucity of all forms of life

is due to climatic factors alone. In a tropical rain-forest, on the other hand, with its wealth of species and predominantly favourable climate, the survival of species and individuals is determined largely by competition resulting in a biological balance. That this competition is severe is surely indicated by the infrequent occurrence of even two individuals of the same tree species together. This biological balance is broken only where edaphic factors strongly favour one or two species, as in mangrove-swamps or mora forest, or where man makes a clean sweep of the original vegetation and plants extensive areas of single plant species, like sugar-cane.

Even when applied to the South American continent and the Caribbean islands, the comparison between continents and islands from the viewpoint of biological control is likely in practice to prove misleading; for if we are right in considering biological factors of predominant importance in the Tropics, it is biological or ecological segregates rather than geographic ones with which we ought to deal. From this point of view, the cane-lands of British Guiana, for instance, form several ecological islands—islands, moreover, covered with one dominant introduced plant, separated from other cane islands of the continent by vast stretches of radically different plant associations sheltering widely different insect faunas. That these biological barriers have been effective is shown by the fact that cane was grown in these areas for some centuries before it was attacked by several of the more important pests (*e.g.*, *Castnia* and frog-hopper) which now ravage it, although these insects are undoubtedly indigenous to the immediate forest hinterland—and had thus been there all the time. It is indicated also by the occurrence in the cane-lands of British Guiana, Venezuela and Trinidad, of three entirely different species of *Diatraea*, as the most important small moth-borer in each case.

A Notable Success.

The parasites of these pests are similarly restricted in their distribution. If, therefore, both the agricultural pests and their present parasites show such strong segregation even in areas so close geographically as Trinidad, the Guianas and Venezuela, we have every reason to expect that new parasites introduced into such ecological islands will prove as successful as in their geographical counterparts. The success of the Australian ladybird in California against the cottony cushion scale was one very noteworthy success of an introduction into an ecological island, albeit part of a continental area.

The second new theoretical consideration based on ecological data is one which has been more or less implied in the recognized technique of biological control work. It is well known that the greatest successes of biological control have been achieved by the introduction of an insect's natural enemies into countries which it has reached without them. The search for parasites has therefore been prosecuted where possible in the original home of the insect concerned. But if the notion of biological islands is sound, and if we desire not only to find promising parasites but also to discover any other limiting factors, the absence of which in agricultural areas may have led to the insect's outbreak as a pest—if, in short, with a view to exploring all possibilities of biological and cultural control we wish to discover why the insect has become a pest, it seems to me that we must be ecologically more fundamental. We must examine the status of the insect in an entirely primitive environment, in a virgin plant-association, and try to evaluate its position in an older and more stable balance than that of the cultivated areas.

Laboratory Limitations.

There is a modern view that progress in animal physiology and ecology is best served by laboratory studies of a given organism under more and more rarefied conditions of single physical environmental factors. This implies the belief that from the accumulation of such data, isolated from all contextual and historical considerations, we shall eventually be able to synthesize an intelligible explanation of the organism's activities in the field. But modern philosophic thought tends more and more to emphasize the fact that wholes show properties which cannot be deduced from those of their parts, still less from their parts under artificial isolation, and the ecologist above all—the student *par excellence* of the inter-relations of organisms and their environment—must face the problem of studying ecological wholes and their properties. He is likely to achieve the most success in those environments which have been least modified by the biological revolutions which every-where accompany agriculture. Thus in the present investigation the primitive environment of a pest has been regarded not only as the most promising source of efficient parasites, but also as the key to its present status and eventual control. Work under these conditions has often involved slow travelling, but the balance is even, since ecological observations can be made from a canoe or a horse better than from a train or a motor-car.

The prevailing impression from a study of the West Indian agricultural pests is one of constant

flux. The attacks of the giant moth-borer, the froghopper, and many other pests began in comparatively recent times. Other, at present harmless, native insects will probably learn to feed upon economic plants. Others again, like the pink bollworm and the banana-borer have recently been accidently introduced. The sudden change of huge tracts of forest to cane culture, from cane to cacao and back again (as in Trinidad), from cacao to coffee (as in Suriname) or cane to bananas (as in Jamaica) upsets whole insect faunas and weed floras. It is time these ecological transmutations were carried out less blindly, and with an eye to biological consequences.

Trinidad has been the base of the mission and was the scene of the first four months' work. All the British colonies have been visited save the Bahamas (from which no requests have come for advice or assistance) and British Honduras, and all the important sugar-cane islands except Porto Rico, Guadeloupe and Martinique. A visit to Porto Rico will be necessary for a proper understanding of the moth-borer situation, in respect of which this island seems to occupy an intermediate position between the greater and the lesser Antilles. There also it may be advisable to procure coffee leafminer parasites for St. Lucia.

It is hardly practicable in a general review to detail separately the effect of the various kinds of ecological conditions. A few examples of their inter-relations must suffice to justify their study in an investigation of this kind. Geographical factors have been paramount in isolating and maintaining two entirely distinct faunas—mainland and Antillean, in the area under discussion. Guiana and Trinidad, though the latter is geographically an island, are continental in character, with an exceedingly rich fauna and flora, and on the whole a considerable number of parasite species attacking the main pests, in some cases without much effect. The dominant vegetation formation is rain-forest, and the present pest situation cannot be properly interpreted without a study of the changes which have accompanied its partial removal. This applies in a varying degree also to the islands.

Greater Antilles Fauna.

The Greater Antilles have a poorer and more specialized fauna, with the more important pests, save the recently-introduced ones, better controlled than in either of the other two regions. Topography influences climate, not only the rainfall directly, but also the relative humidity under conditions of equal rainfall. And the three, together with the relative density of the population, have largely determined what proportion of a given colony still remains under the forest covering, which in most cases was originally the dominant vegetation. This proportion, it may be readily seen, exercises a very considerable influence on the biological balance, in such matters as alternate plant hosts for pest-insects and subsidiary insect-hosts for useful parasites.

Biological Factors.

Turning now to purely biological factors, insectivorous birds are almost certainly much more important agriculturally in the tropics than in the temperate regions. Not only is there an abundant avifauna throughout the year, but in the northern winter the West Indies receive countless myriads of migratory small birds which are wholly insect-eating, and a host of waders which are much more insectivorous than most ornithologists imagine. And there is in addition a group of very efficient and entirely ubiquitous predators which in temperate regions are of no moment, but in the tropics probably account for more insects even than do the birds. I allude to the lizards, and especially the small plant-haunting species of the genus *Anolis*, which are frequently present in incredible numbers and have been shown to feed upon a variety of pest insects.

We must recognize that most of the problems with which we have to deal are due solely to the introduction, intentional or accidental, of foreign organisms. It is thus singularly appropriate that we hope for a solution from an extension of the same process—"a hair of the dog that bit us." Most of the chief crop plants and a high proportion of their major pests have been imported into the islands where they now bulk so largely. The inter-relations of these foreign organisms among themselves and with the indigenous plants and animals must, then, form an integral part of every pest-problem we take up. There are, however, more general problems of this nature consequent not on the necessary acclimatization of foreign crops nor on the accidental entry of exotic pests, but on early deliberate attempts at biological control.

The effect of the general introduction of European cats and dogs seems to have received little attention. It is probable that their influence on the indigenous West Indian fauna has been much less devastating than in New Zealand, where more than one endemic species has been indubitably exterminated by the domestic cat, while dogs are to-day among the worst enemies of the kiwis (*Apteryx*). On the small West Indian island known as Swan Island, cats are believed to have exterminated a local lizard and a thrush. European dogs, trained for the purpose, are said to have taken a large part in the extermination of the

aboriginal Indians in Hispaniola, under the Spanish. This was one of the first instances of biological control in the New World! Feral dogs of European stock are by no means uncommon in the Cuban mountains, and, at least up to 1850, in Santo Domingo. They are pests of stock, but I have not heard that they have caused much destruction to the native fauna. The domestic cat I have seen in the suburbs of Port-of-Spain with a ground-lizard in its mouth. This is important for two reasons if it be a general habit—firstly, the lizards of this genus are known to be among the most useful insect-eaters; and secondly, wherever the mongoose has become established, it tends to extirpate these lizards everywhere, save in the immediate vicinity of towns.

Introduction of Birds.

With regard to the introduction of insectivorous birds, it is extremely doubtful whether this is ever necessary or advisable in any of the West Indies. Efforts should rather be directed towards the active protection of the indigenous species already present, albeit in some cases in depleted numbers. This protection should, above all, take the form of supplying cover, and in drier islands, drinking-places. Two introductions have been so widespread and have modified so profoundly the biological balance almost throughout the area that they necessitate more detailed discussion here. I allude to the artificial distribution of the giant toad from the mainland, and the importation of the mongoose from Southern Asia.

Unlike most amateur attempts in this direction—witness the many deplorable cases in New Zealand—the introduction of the giant toad seems to have been followed by no conspicuous ill-effects. It is true that in Jamaica, at least, it was early accused of eating young ducklings, while an investigator says "it feeds upon small batrachians, and may extirpate some native species, though as yet it seems a worthless but guiltless introduction." But it certainly eats many insects. In Trinidad its stomach has been found crammed with mole-crickets, while in Barbados one specimen was found to contain forty leaf-caterpillars of a destructive type. Apparently it was first introduced from Cayenne into Martinique and thence to Barbados, whence Jamaica obtained a stock, all before the middle of last century. Curiously enough, it was originally brought in to destroy rats—then by far the most destructive pest of sugar-cane. They had been considered in Barbados very important auxiliaries to the planter in this work, by their pursuit and destruction of the young rodents. It is much to be doubted whether they were ever active in this direction. Be this as it may, they are now well adapted to agricultural conditions and exceedingly abundant in many of the islands. Both in Antigua and Barbados, and probably elsewhere, they are preyed upon by the mongoose.

This brings us to the most important attempt at biological control which has yet been made in the West Indies—the introduction of the mongoose for the suppression of rats. The first and most serious agricultural pest ever recorded from the West Indies was the "blast," which was somehow associated with ants, but which still remains, in the words of an investigator, "an unsolved riddle in the history of economic entomology." In 1518 and the two succeeding years this trouble was so serious, causing wholesale destruction of vegetation and widespread famine, that the whole island of Hispaniola was almost abandoned. The next plague was apparently that of black rats, already a serious pest in the French islands by 1654. In 1789, it was estimated that the rats often destroyed a quarter or more of the Jamaican cane crop. Large sums were expended annually on trapping and other measures of direct control.

The first attempt at biological means, other than the use of dogs, was apparently the introduction of ferrets from Europe; these were alleged to have been incapacitated by the attacks of burrowing fleas. Then about 1750, Sir Charles Price hit upon the notion of importing a South American carnivore which would be adapted to the attacks of the insects. These animals appear not to have become established and their very identity is quite enigmatical, but the negroes were impressed with something rat-like in their appearance, and named them "Charley Price rats." One Thomas Raffles, in 1762, is credited with the next attempt at an abatement of the increasing plague. He is said to have introduced from Cuba an ant, *Formica omnivora*. Later still, the giant toad was imported. Meanwhile the rats increased, not only in Jamaica but also in the other islands. In Barbados from 1875 to 1879 the Government paid for 654,459 rats' heads at a penny a piece.

Spread of the Mongoose.

Finally, the mongoose was introduced, first apparently into Trinidad (1870) and later in the 'seventies or early 'eighties into most of the other islands. To Jamaica four pairs were imported in 1872 direct from Calcutta. They multiplied and spread so rapidly and attacked the rats so vigorously that ten years later they were credited with saving the island £45,000 per annum. In most of the islands, between ten and fifteen years after the introduction of the

mongoose, public opinion of it made a complete *volte face*. Rats, though diminished, were still abundant, and the mongoose was said to be destroying many ground-nesting birds, lizards and toads, while its depredations on the poultry were wholesale. There was alleged further a great increase in insect pests due to the killing of insectivorous vertebrates by the mongoose.

In Jamaica, where the damage by rats in cane-fields seems to have been most severe, this phase of public disfavour passed very soon, and the mongoose is still considered to do more good than harm. The same opinion prevails in Martinique and in St. Lucia where the animal was imported to suppress the fer-de-lance snake.

Sugar-cane is, of course, the most important crop of the British West Indies and British Guiana. In the present investigation its pests have, therefore, received the most attention. In no other case was the lack of fundamental biological data marked as in that of the small moth-borers, unquestionably the most serious pests of sugar-cane throughout tropical America. On some estates in Guiana and Trinidad gangs of fifty or more men, boys or girls, are employed permanently to cut out shoots killed by borers, from which the larvae are extracted for counting and payment at so much a hundred.

Rearing Egg Parasites.

Egg-clusters may also be collected. In British Guiana, under the supervision of either a consulting or a resident local entomologist, it is a common practice to breed out either the egg-parasites or the larval parasites or both, and liberate them in the fields. A very large and effective plant for rearing many millions of the egg-parasite, *Trichogramma*, has been erected in Barbados, using as host-eggs those of the corn moth, *Sitotroga cerealella*.

A preliminary study has been made of a new citrus pest which is increasing in importance. This is an indigenous stingless bee which attacks very severely the improved grape-fruit which is being brought into extensive cultivation in Trinidad, British Honduras and elsewhere. It bites the young shoots apparently to collect the resinous sap, and may in extreme cases completely kill three-quarters or more of the main shoots. The fruit also is attacked and ruined. The huge nests are placed often high up in trees, frequently at some distance from a cultivation, and are hard to locate.

Unfortunately our ignorance of the biology of these bees is immense. We are only at the beginning of their study. In the meantime the only feasible line of attack is to locate and destroy the nests with calcium cyanide. These are fortunately few and far between, and when found represent enormous centres of population. The efficiency of this method is, however, linked up with the distance the foraging bees ordinarily fly from the nest, and on this point we are entirely ignorant

Correspondence.

ARCTIC TOURS.

To the Editor of DISCOVERY.

SIR,

The Soviet icebreaker *Maligin*, has left Archangel with a party of tourists aboard, for a six weeks' cruise in the high latitudes of the Arctic. Thus, for the first time tourists are penetrating into the very heart of the Polar regions, hitherto visited only by explorers and whalers. Many travellers who, like myself, have participated in a cruise which included a visit to Spitzbergen, have been very disappointed with the brief period allocated to that part of the programme.

Would it not be possible for some progressive concern to organize an itinerary similar to that which the *Maligin* is undertaking but of shorter duration? Has not the time arrived now when the fascinating beauty of the Far North might be brought within the reach of the ordinary tourist? I venture to think that such a move by one of the more imaginative of our organizations would meet with wide and enthusiastic support.

Apart from the strangeness of the surroundings—the grandeur of the colossal glaciers and ponderous ice-fields, the spectacle of the midnight sun, the lavish colouring, the whaling and hunting grounds—the educational value of such a trip is obvious. Sooner or later such an itinerary must surely be arranged, for the demand for it is increasing; and shall not Britain be foremost in this matter, as in all others connected with the sea and its ships?

Yours faithfully,

Guildford, Surrey. R. BRIAN LEIGHTON.

"BALL" LIGHTNING.

To the Editor of DISCOVERY.

SIR,

The reference to "ball" lightning in a recent issue of *Discovery* recalls a remarkable experience of my uncle in 1835. While at New Orleans on the Mississipi river he was observing the weather in the course of his duties when suddenly a ball of fire fell from the sky accompanied by a sharp fall of rain. The ball ran down the mast of the ship, and passing through my uncle's hand, it fell into the water, where it exploded with a loud report. Greatly to his colleagues' surprise, the captain was undamaged by this experience and the only discomfort he felt was a slight stinging pain in the hand, accompanied, curiously enough, by a buzzing in the ear which lasted for fully a week. I discovered an account of this interesting experience in a letter which my uncle wrote a few days later. By that time the discomfort had entirely disappeared and the hearing in both ears was again normal.

Yours faithfully,

Portland, Maine, U.S.A. JAMES A. SPALDING.

Book Reviews.

The Stone Age Cultures of Kenya Colony. By L. S. B. LEAKEY. (Cambridge University Press. 25*s.*).

The author has enjoyed a good fortune accorded to few pioneers in archaeological discovery. The announcement of his find of relics of prehistoric man in Kenya was immediately hailed as of the first importance. Subsequent investigations have not merely confirmed early conclusions; they have broadened and extended them until it is now patent that to future generations of archaeologists the work of the East African Archaeological Expedition, organized and led by the author, will appear as epoch-making. It may be necessary to modify or expand Mr. Leakey's interpretation of the evidence in the light of further discovery, as the second season's results have led to the revision of earlier deductions; but his investigations will always serve as a key position in the study of the succession and distribution of stone age cultures in Africa, and, it may be, over even a wider area.

In this book the author reviews and discusses the results obtained by his work in the field in the two seasons 1926-7 and 1928-9. Reports embodying detailed accounts of the excavations on individual sites are reserved for future publication for the benefit of specialists. The circumstances of Mr. Leakey's discoveries are sufficiently well known by now to make detailed recapitulation unnecessary. Before his investigations the existence of a stone age culture in East Africa had been made known by a number of discoveries, although it was barely admitted that of these some were palaeolithic. The discovery of human remains in pleistocene deposits by Dr. Hans Reck just before the war had, naturally in the circumstances, received little attention; and there were no artefacts with the skeleton. In 1924 Major Macdonald announced in *The East African Standard* the discovery of implements and fragments of human bone on a site of peculiar character at Nakuru. Acceding to Mr. Leakey's request, he left the site undisturbed until the East African Archaeological Expedition took the field in 1926. Excavation revealed that it was a burial of a human skeleton, which proved to be of non-negroid type, associated with relics of a neolithic culture. Subsequent investigations on a number of sites at Elmenteita, Nakuru, Naivasha and elsewhere have brought to light a series of stone age cultures, following one upon the other from earliest palaeolithic of Chellean type down to neolithic in a succession more or less equivalent to the succession of stone age cultures in Europe, and to main features in the South African stone age.

The full significance of the author's work, however, lies in the implications of the geological evidence. Each of the cultural phases distinguished by Mr. Leakey on archaeological and stratigraphical evidence stands in definite relation to deposits left by lacustrine waters at varying levels. Of these some are as much as 620 feet above present lake level. The varying levels of these deposits, of which the earlier are judged to be of pleistocene age, are interpreted as evidence of periods of pluviation. These pluviations, which are thus brought into association with the various phases of culture, are, it is suggested, to be correlated with the periods of maximum glaciation—Gunz, Mindel, Riss and Würm as they are termed by the geologists—of the Ice Age in Europe and with later lesser variations of climate in that continent. Further, they correspond in a remarkable degree with the results of observations of a kindred nature in Palestine and with conditions in the Nile valley; while it has been suggested tentatively that certain evidence in South Africa is to be interpreted in a like sense. The evidence in favour of regarding the Kenya pluviations as part of world-wide phenomena, and not as of purely local incidence, is discussed by Mr. C. E. P. Brooks, the meteorological authority, in an appendix. It cannot be considered here; but enough has been said to indicate the vital significance of this work in its relation to the problems of prehistoric chronology.

The matters to which reference has been made by no means exhaust the problems with which Mr. Leakey has had to deal, such, for example, as the contemporary occurrence of Mousterian and Aurignacian phases of culture, which until recently have been regarded as successive in the order named. Then again there is the question of the origin of Aurignacian culture which the Kenya discoveries raise inevitably, but for which they as yet offer no decisive evidence towards a solution, though the author has two alternative theories to suggest. These and many other points of equal moment it is not possible even to mention here, much less discuss. Finally a word of praise must be given to the generous selection of illustrations which are of the greatest assistance in following the author's argument.

An Introduction to Plant Physiology. By W. O. JAMES. (Humphrey Milford. 7*s.* 6*d.*).

There has long been a wide-felt need for an up-to-date text-book of plant physiology, to serve as a reliable introduction to the subject and to take into account fundamental results of recent research. This book is produced to supply the need for a senior school or junior university book which gives a well-balanced and connected description of the elementary aspects of the subject, accurate in the light of established results of recent work.

The first chapters give an account of the chemical transformations which take place in the plant and make up its metabolism. Here are given descriptions of photosynthesis, the chemistry and occurrence of carbohydrates, nitrogen metabolism, and the processes of respiration and fermentation. Next, the living basis in which these chemical changes occur, the protoplast is considered, and subsequent chapters are devoted to the water relations of the plant, irritability, and growth. Physical and chemical details are given, where necessary, throughout the book, but especially in the first few chapters. Complexity is avoided and sufficient and clear explanation given to render this aspect intelligible and interesting to those with only a slight acquaintance of chemistry.

As a text-book of intermediate nature this is very thorough. It embodies the results of recent research and work available only in special papers and monographs. Thus, the physical details of gaseous exchange through the stomata are given and the importance of light as a conditioning factor is explained. The description of respiration is in accordance with the recent papers on the subject, and shows a great advance on older text-books. The distinction, seldom made, between anaerobic respiration and fermentation is pointed out. Other items of special interest are the passage of water across the root from root hair into xylem vessel, and the redistribution and chemical transformation of food materials within the plant at critical periods of its life history, for example, at seed formation and germination. Soil is considered chiefly from the point of view of its nitrogen balance and further details of its structure and composition are given rather briefly, in connexion with the water

relations of the plant. Experimental work suitable even with minimum equipment, and fully described, is appended to each chapter.

Being of moderate size and essentially a book for school or junior university students, controversial matter and theoretical discussions are avoided as far as possible, and the historical aspect is omitted, although the latter would have added to the appreciation of present attainments in plant physiology. Also, in places, the account ends rather abruptly when only the most outstanding points have been given, as in the section on enzymes. The book brings in the results of much advanced work, but acts as a comparatively simple summary of the present situation in plant physiology, and sufficient and clear explanation is given in passing to make the reading easy. Clear illustrations, mostly original, add to its value. It would give the university student a good basis from which to elaborate more specialized work and provide a sound introduction to the subject for senior forms in schools.

Life by the Seashore. By MARION NEWBIGIN. Rewritten by RICHARD ELMHIRST. (Allen & Unwin. 7*s.* 6*d.*).

There is no region which is so prolific of most diverse types of animal and plant life, from protozoa to fishes, from blue-green algae to flowering plants, as the seashore, nor one where the constantly changing conditions make greater demands on those powers of adaptation which are the most fundamental property of living matter. There is no more ideal region for the study of life; the patient observation of the naturalist, the experimentation of the physiologist, and the enthusiasm of the amateur, all find unlimited scope between the tide marks round our shores. Many books have been written about the life of the seashore and none better than this, which was first published thirty years ago and was reprinted in 1907. It has been out of print all too long and its re-appearance will be a source of gratification to all marine biologists, professional and amateur alike. The book has been re-written and extended by Mr. R. Elmhirst, Superintendent of the Marine Biological Station at Millport, and probably the most experienced shore naturalist in Scotland.

Much has been added to our knowledge of shore life in the last quarter of a century and Mr. Elmhirst has been most successful in grafting this on to the original matter. The introductory chapters, which have been entirely re-written, form one of the most admirable accounts of the general conditions of shore life that we have ever read. It could only have been written after long and careful study of animals and plants and of the rock-pools, sandy beaches and mud flats in which they live. Passages which reveal the born naturalist are continually encountered: "It is necessary, also, to emphasize the necessity for handling specimens freely. The healthy child instinct to touch everything seen is so thoroughly educated out of most people that they never seem to realize how enormously sense impressions are strengthened when hand and eye work in combination. In studying zoology, therefore, from the first train your fingers and let hand and eye co-operate with the pencil." The nomenclature throughout has been revised on the basis of the new fauna list of the Marine Biological Association of the United Kingdom and, though many will regret the passing of the old names, it is well that these corrected names should be widely known and that the coming generation of shore naturalists should acquire them from the beginning.

We hesitate to find any fault with so delightful a book, but a protest must be made against the description of the crystalline style of the Lamellibranchs as a reserve of albuminoid material, which was the current belief when Dr. Newbigin's book originally appeared. It will not, we hope, be long before an opportunity arises for the correction of this error, for no book on shore life deserves a wider or more continuous sale than this delightful volume.

With the Migratory Birds to Africa. By BENGT BERG. Translated by F. R. BARTON. (Jonathan Cape. 10*s.* 6*d.*).

In his youth the author was fascinated by the sight of the autumn migration of the grey or common cranes (*Grus communis*, sometimes called *Megalornis grus grus*) as, in huge flocks, they flew southwards over his Swedish home in a constant stream "from the earliest dawn till the evening stars twinkled in the sky." Thenceforward the migration of the cranes became a passion to him and he was consumed with the desire to follow them. This book tells how his wish was fulfilled, but not till after he had tracked them to their nesting haunts in Lapland. It took him four years to find the eggs and several more elapsed before he discovered a nest which he could photograph. The pictures of the parent birds and their young are remarkably clear and lifelike.

Having discovered their nesting haunts Mr. Berg turned his attention to tracking them to their winter quarters. First he tried Spain, where, indeed, he found his birds but not in the numbers he had expected. So he set forth for the Nile. But though in Egypt there was plenty of bird life in and about the river there were no cranes, not even when he reached the confluence of the Blue and White Niles at Khartoum. So he chartered a boat and sailed up the White Nile, and here at last he found the grey cranes which he had sought so long. They were scattered in myriads over the dried-up millet fields, flying in phalanxes in the cloudless tropical sky, and stalking in countless thousands on the banks of the river. Their favourite winter quarters, he says, lie from the desert region south of Omdurman on through Kordofan as far as Abu Seid: beyond this other species of crane were commoner. The various ruses which he practised in order to get his photographs are entertaining: the pictures themselves are evidence of his success. The author's interest was not confined to grey cranes; he photographed, among others, demoiselle cranes, storks, and ibises. From a hide near the remains of a hippopotamus harpooned by natives he watched vultures, crows, kites, marabous and others squabble over a ghoulish feast. On another occasion he filmed a fight between two crocodiles. The common crane nested in England up to the end of the sixteenth century. If unmolested it might do so again.

This is a fascinating book; it avoids the dullness which often unnecessarily disfigures a purely scientific treatise, and for this reason will appeal not only to ornithologists but to the general public. It would be improved by an index.

Egyptian Temples. By MARGARET A. MURRAY. (Sampson Low. 12*s.* 6*d.*).

Of the Ancient Egyptians Herodotus says: "They were the first to assign altars, images and temples to the gods," and then he proceeds to record some of the marvels he himself had seen, and more that he had been told, in that wonderful land, thereby earning for his pains a reputation for mendacity of which he has been relieved only by the researches of modern scholars

and archaeologists. It may or may not be that Herodotus was correct in saying that the Egyptians were the first to raise temples to the gods. Certainly no people in antiquity was more assiduous in according the gods this honour.

Miss Murray's object in writing this book, she explains, has been to provide something between the guide-book (incidentally some of these, written by experts, are excellent) and the detailed treatment of the volumes of the specialist. No temple is described exhaustively, nor is any attempt made to give a complete list of the temples. But brief and lucid descriptions and an ample supply of plans and photographs of the temples on the principal sites between Gizeh and the limits to which the Egyptians carried their arms on the upper waters of the Nile provide more than adequately for the requirements of those who wish to know something of the types and development of the Egyptian temple. It is needless to add that the author has done her work conscientiously and well.

The Egyptian temple is a subject of many-sided interest. In an introductory chapter the author sketches rapidly the course of its development from the palisaded structure of mud and reeds and the use of brick until the Egyptian learnt to handle stone—the art in which Ancient Egypt ultimately developed the highest technical excellence. She also illustrates freely the development of the column from the bundles of papyrus plants with their flowered heads for which the lotus and lotus bud were substituted to form the capital when the column had been translated into stone. In lighting effects the Egyptians showed remarkable skill. As will be noted in some of the examples to which the author refers, in this matter they readily adapted their type of building to the requirements of belief, whether stress was laid on the mystical element in the darkened hall or in its relation to the light of the sun as in the temples, open to the sky, of the Aton worship.

In addition to her numerous and necessary references to the worship of the greater deities of the Egyptian pantheon and the cult of the dead ruler, the author frequently has occasion to touch on lesser, but in some ways more interesting, cults and festivals, such, for example, as the *set* festival, of which the meaning is still not entirely clear. In several cases these observances last on into Christian and Moslem times, as when we find the cult of a Mohammedan saint perpetuating the memory of the ceremonial marriage festival of Amon and a Theban princess. On the Upper Nile in Egyptian temples taken over by the Christians the ancient Egyptian gods and kings become Christian saints under the magic touch of a brushful of paint.

It may be that some readers will feel a little bewildered by the references to the tangled mass of Egyptian divinities notwithstanding Miss Murray's expository remarks, and a more formal outline, however brief, of the main features of Egyptian religion would have been an advantage, as also might a list of Egyptian rulers. It is true that these details are available in any book of reference on Egypt; but books of reference are not always at hand, especially among those to whom Miss Murray's book will be of most interest.

Methods of Choosing a Career. By F. M. EARLE. (Harrap. 12*s.* 6*d.*).

Some years ago the National Institute of Industrial Psychology undertook a great experiment. Twelve hundred London children, about to leave their Council schools, were studied individually by trained investigators with a view to determining, if possible, the vocations to which they were best adapted by nature. The after-careers of the children have been watched and recorded, and the inquiries, directed by Mr. Earle under the guidance of Dr. C. S. Myers, the Principal of the Institute, are now in a position to sum up the results and to say definitely that the vocational guidance offered by an expert to a child leaving school is on the whole worth while. The book written by Mr. Earle and his colleagues describes their methods in detail. It inspires confidence because it does not claim too much. The Institute workers are free from dogmatism. They recognize the infinite variety of the individual and his circumstances. They do not try to pronounce upon children in the mass as if they were so many sheep or turnips, after the Muscovite manner. They admit quite honestly and without a show of vexation that the advice which they gave to half the number of children whom they saw was often disregarded and not invariably sound. They spent about ten hours, or two school days, upon each individual case, but they do not profess to have detected all the idiosyncrasies of every child. Such modesty and caution, contrasting strongly with the self-assurance of some practitioners of this new science, increase the value of the book and reinforce its conclusions.

The general aims of the experiment and the methods adopted are first described in brief. Then we have a detailed and interesting account of the several aspects of the vocational study of the child, in his home, physical and mental conditions and in his character, with the standards by which investigators form their recommendations. The main features of various occupations are then outlined, as a preliminary to a thorough examination of such information about the children's after-careers as could be gathered from them or their friends or from employers' reports. This material is analysed very thoroughly; the lay reader is given a summary in plain language while the expert is provided with technical particulars. Finally, Mr. Earle reviews his results and maintains that "it is possible in some considerable measure to forecast vocational success." He is fully conscious, however, that the individual's wishes and personal predilections have a great deal to do with his success or failure in any given post. Dr. C. S. Myers contributes a hopeful preface, in which he looks forward to the wider use of psychological methods for the benefit of our young people, and Lord D'Abernon, the President, in a foreword recommends parents, employers and others to make fuller use of the Institute.

Turi's Book of Lappland. By JOHAN TURI. Translated by E. GEE NASH. (Cape. 7*s.* 6*d.*).

Turi is a Fell-Lapp, one of the nomad race that lives with the reindeer herds throughout the year, following them in their southward migrations in winter and back to the northern Fells in spring. His object in writing this book was to explain the Lapps' mode of life, and their resentment at the encroachments on their ancestral lands by settlers. "The Lapps' land has grown so small that the Lapps can no longer support themselves." Yet no Lapp can explain their circumstances to the authorities because "When a Lapp gets into a room his brains go round. . . . He can't think quickly within four walls."

The hardships of the Fell-Lapps' life are described very vividly and the author's naive narrative is assisted by his own pictures, which, though their technique recalls the Bayeux Tapestry, are graphic representations of typical episodes. There are long journeys, often in the dark, over snowy wastes, with strings of reindeer, some pack-laden or drawing sledges, and the others in

herds which have to be watched all night lest they wander away or are attacked by wolves. There are rivers to be crossed; sometimes the sledges and reindeer are swept away by the current, or, if the reindeer are contrary, it may take a week to get the herd across. There is a chapter on the hunting and trapping of wolves, wolverines, bears and elks. One way of catching a bear is to make him drunk. An intoxicating drink called "brännvin" must be put in a blue crock under a juniper bush; "it must be blue because blue is the colour of the sky and so the bear isn't afraid of it." The bear will drink till he loses his senses.

In the old days there were no doctors among the Lapps, but they had their own quaint and sometimes barbarous remedies. Bleeding and rubbing figure in many of these cures. Others comprise the application of a frog to the affected part, or drinking milk in which a frog has been cooked. Aids to women in childbirth are described in detail; the methods are rough and ready—it must often be a question of kill or cure. A race living among forests and mountains, where for two months of the year there is almost total darkness, naturally possesses a rich folk-lore. "Stallos are those folk who are half human and half troll or devil"; they hate mankind. There is a gruesome story of how a Stallo killed and cooked some children at Yuletide. Uldas are a strange folk, who, though they sometimes steal the Lapps' children and substitute changelings, are often kind to them, and tell them charms against their enemies.

The book is a weird mixture of fact and superstition. But it gives us insight into the inner life of a primitive race and arouses our sympathy for them in their unequal contest with the forces of civilization. Turi's book ends thus: "Finally, we are in God's care, like a child on its mother's knee, where it has its best refuge."

The Problems of Evolution. By A. W. Lindsey. (Macmillan. 8*s.* 6*d.*).

In this volume the author sets out to discuss the existing state of evolutionary theory in a non-partisan manner, with the intention of forming a background on which to base future lines of research. Most aspects of the problem are touched on and the necessity of linking the hereditary basis with that of the environment is insisted on. While the general trend is to admit the importance of all factors, the author evidently favours the environment as one of the main controlling influences in evolution while realizing that the organism and the environment are so much of an unity that heredity must be given an equally important place. He rightly maintains that perhaps too much attention has been given to weighing the importance of one theory against another and emphasizes that as all factors are essential no one can actually be of greater importance; research should rather tend, therefore, to find out how the various factors interlock. Since one main theme is not upheld throughout, the reader is perhaps left with a feeling of lack of co-ordination in the work; but this only tends to emphasize how complicated the whole field is and the fact that the problems must be looked at as a whole and cannot be separated.

Professor Lindsey eliminates for the time all vitalistic theories and advocates that our only hope of solution at the moment lies in experimentation and the adoption of a mechanistic outlook; he maintains that research should centre more on observing the effects of a gradually changing environment, an attempt being made at the same time to see if certain characters thus brought out may have a usefulness under other conditions than those which determined their production. The book is written for those who are already well acquainted with the history of this branch of learning, and as such is a fair statement of the present position of evolutionary enquiry written in an unbiassed manner. It conveys well the truth that at present a logical picture can only be gained by a combination of such factors as natural selection, isolation, mutation, pre-adaptation, heredity and environment, and that in reality we are no nearer the solution of how our present species have been brought into being.

On page 153 the author refers to Loch Leven trout, Great Lake trout and English Brook trout as "actual species of the accepted classification." This is only a small error in a very readable book.

Planning for Good Acoustics. By Hope Bagenal, A.R.I.B.A., and Alex. Wood, M.A., D.Sc. (Methuen. 22*s.* 6*d.*).

This book is intended primarily for the use of architects and builders, and is a comprehensive survey of the question of acoustics from every point of view. Realizing that the fundamental factors "for good and bad acoustics are not all new," the authors have not ignored the historical side and in each section of the work the principles of the past are given the place with the advance research of the present.

In these days of continually increasing traffic of a heavy nature the question of noise and reverberation is acute. The authors pay particular attention to this matter, and go very thoroughly into the possibilities of prevention and cure of the additional menaces to architectural problems through the use of sound absorbing and insulating materials. Very rightly they stress the importance of closer collaboration on the part of the physicist and the architect, holding the view that "science in its contribution to technology is for ever raising new problems and offering insufficient data for their solutions. In architectural acoustics the physicist is alone capable of analysing the processes involved." A section entitled "Special Requirements," dealing with recording and transmission, is of particular interest. The vast strides made in recent years in the recording of gramophone records and the transmission of wireless programmes owe a considerable debt to the research of the experts in acoustics. A great deal from the acoustic standpoint has been done to improve the recording of sound and talking films, but much remains to be done. The authors discuss at some length the problems which confront the producer of the talking film and the recorder of gramophone records, and realizing that one of the primary difficulties is the construction and ventilation of the studio they devote several pages to the building of film studios and sound-recording rooms for gramophones.

Although the book is intentionally specialized it reads easily and is not too technical in style. There are chapters on the construction of opera houses, concert halls, theatres and kinemas which the general reader and those interested in music, drama and the kinema will find interesting. In particular Chapter XVI, "Historical Development of Buildings Acoustically Planned," which traces the evolution of the theatre from the day of the Greek theatre to the modern theatre and concert halls and the kinemas of Germany is of great value, embracing as it does the Elizabethan theatre—that of Inigo Jones, the Italian opera house and the Wagner Festival Theatre at Bayreuth. The book is well illustrated, the illustrations ranging from plans and formulae to photographs of the buildings described.

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